

PROCEEDINGS  
OF THE  
NATIONAL ACADEMY OF SCIENCES  
INDIA  
1964

---

VOL. XXXIV

SECTION - B

PART III

---

OCCURRENCE OF VIRUSES OF TOMATO AND THEIR PROBABLE  
STRAINS AT KANPUR

By

D. V. SINGH and S. B. LAL\*

*Department of Plant Pathology, Govt. Agricultural College, Kanpur*

[Received on 12th December, 1963]

Tomato (*Lycopersicum esculentum* Mill.) is an important vegetable crop grown extensively throughout India. This crop is reported to suffer from at least nineteen diseases of virus origin alone in the world (Smith, 1957). The symptoms due to these viruses are much varied and range from mild mosaic through severe mosaic, leaf curl, bushy stunt and wilt to severe necrosis. Only a few virus diseases have been observed to infect this crop in India, nevertheless the incidence of some of them is very high.

No systemic survey of virus diseases infecting tomato crop has been made in Uttar Pradesh. The present work was therefore initiated to find out the nature of virus-like symptoms produced in tomato crop and to identify the various viruses and their strains, if any, infecting this crop in Kanpur. The incidence of big bud and leaf curl of tomato was as high as 10% and 25% respectively. There is a great variation in the symptom picture of leaf curl of tomato. This indicates either the presence of several strains or different reactions by the host varieties. The possibility of the occurrence of strains of this virus has been emphasized by Storey (1932), McClean (1940) and Vasudeva and Samraj (1948).

**Symptoms :**

Out of large number of diseased plants of tomato collected from different localities of Kanpur seven typical specimens showing virus-like symptoms were studied and their symptomatology is described below :

---

\*Now Director Central Coconut Research Station, Kayangulam, Kerala.

TABLE I  
Showing field symptoms of diseased tomato plants

Sample	Date of collection	Variety	Intensity of disease	Characteristic symptoms
B	14.12.60	Pan American	*Mild	Slight leaf curl, leaflets twisted, reduction in size not pronounced.
E	22.10.60	T's suix	*Mild	Slight leaf curl with green vein banding, leaves deep green in colour and crowded together.
D	11.1.61	Perfection	*Mild	Leaf curl with upward rolling of margins. Islands of golden yellow colour scattered in the normal green tissue.
A	14.12.60	Pearl Harbour	**Intense	Leaf curl with green vein banding, terminal leaflets reduced in size.
F	11.10.60	--	**Intense	Leaf curl with vein clearing and mosaic, leaf size reduced.
C	14.12.60	Marglobe	†Severe	Severe curling and reduction of leaves with terminal leaflets extremely reduced and rachis often twisted (Fig. 2C).
G	11.10.60	Bombay Best	—	Plants typically erect with thick stem and pedicel and abnormal flowers. Calyx bladder-like. Axillary shoots produced dense rosette-like structures (Fig. IB.).

\*The word "mild" as used here stands for the type of leaf curl in which there is only little change in the size of leaves.

\*\*The word "intense" stands for the type of leaf curl in which terminal leaves and leaflets become reduced to three fourth or even half of the normal size but the leaves situated below show only little change.

†The word "severe" stands for the type of leaf curl in which terminal as well as basal leaves are considerably reduced in size and the leaflets of terminal leaves become so much reduced that only lining of lamina remains attached to the vein.

#### Materials and Methods :

In an attempt to find out the viruses occurring in tomato crop in Kanpur, plants with virus-like symptoms were collected throughout the growing season from various localities in Kanpur. The samples were assigned arbitrary identification marks from A to G and their most characteristic symptoms were recorded.

Infected plants were transplanted from the field in 10" pots and kept in insect-proof cages after spraying with an insecticide. These plants were used as a source of inoculum throughout these studies.

The aforesaid seven samples were first tested for the virus nature of the disease. This was followed by the identification of the causal virus and the diagnosis of disease by making further studies with each sample. Seeds obtained from various sources were sown in 12" pots after being treated with Agrosan GN. Seedlings were transplanted in 4 or 6" pots often in 2 leaf stage.

All experimental work was carried out in insect-proof cages. Plants inside the cages were kept insect-free as far as possible by regular sprays of Basudin twice a week.

Plants in three leaf stage were used for mechanical and insect transmission work. Slightly older plants were preferred for making the grafts. Standard extract obtained by adding one ml. of water per gram of leaf material was used for mechanical inoculation after mascerating and squeezing through cheese cloth. Carborundum powder was used as an abrasive. Regarding graft transmission, cleft grafting was practiced in all the experiments. For insect transmission work small insect cages consisted of a transparent plastic container with a spring controlled lid at the open side were used for feeding purposes. Insects collected from field were fed on healthy tomato plants to test whether they already carried any virus in them. After feeding on diseased plants the viruliferous insects were fed on healthy test plants. Only white flies (*Bemisia tabaci* Gen.) were used in these tests.

In cross-protection tests six plants were taken, of which three were infected with viruliferous white flies (*Bemisia tabaci* Gen.) carrying a particular strain and rest three were kept as control. When systemic symptoms appeared viruliferous insects carrying another strain were fed on test as well as on control plants. The presence of one strain always prevented the infection by the other strain thereby indicating that the strains were quite closely related.

Healthy controls were used in each experiment. Inoculated plants were kept apart to avoid leaf contact as far as possible.

### Experimental Results :

To find out if the various types of symptom were due to varietal reaction or due to the presence of several viruses or their strains, transmission studies were carried out. Variety Prosperity of tomato was uniformly used throughout the experiment to establish the virus nature through graft and insect transmission.

In transmission tests with specimens A, B, C, D, E and F it was found that their disease was easily transmitted by grafting and white flies (*Bemisia tabaci* Gen.) to *Lycopersicum esculentum* Mill. and that it was also transmitted to *Datura stramonium* L., *Nicotiana rustica* L. and *Nicotiana glutinosa* L. The disease of specimen G was transmitted to tomato by grafting and dodder but not by white flies (*Bemisia tabaci* Gen.) and sap inoculation. It was also transmitted to *Datura stramonium* L., *Nicotiana rustica* L., *N. tabacum* L., *Solanum melongena* L. and *Dolichos lablab* L.

TABLE 2

Showing reaction of various specimens on differential var.  
Prosperity of tomato and other hosts.

Specimen	Symptoms on variety Prosperity	Symptoms on other hosts
A	The young leaves showed symptoms of vein clearing, light yellow mosaic and wrinkling of surface. In advanced stages only symptoms remained as mosaic and slight leaf curl. (Fig. 2A).	<i>Datura stramonium</i> L. The new shoots showed marked stunting and yellowing of leaves with slight puckering, wrinkling of surface and malformation. Later on the edges of the leaves turned upwards with light yellow mosaic symptom. In the advanced stages interveinal puckering became quite prominent with wavy margins.

Specimen	Symptoms on variety Prosperity	Symptoms on other hosts
		<p><i>Nicotiana rustica</i> L. The leaves were malformed, reduced in size and exhibited intense curling. The veins on the under surface of the leaves were considerably thickened. The new shoots showed marked stunting and the leaves became rough and brittle.</p> <p><i>Nicotiana glutinosa</i> L. The new leaves developed light yellow mosaic mottling, cupping and reduction in size. The shoots were also remarkably reduced in size.</p>
B	The leaves developed prominent vein clearing, severe curling and thickening of veins with occasional chlorotic areas. The plants were stunted resulting in crowding up of leaves. The leaflets also became bunched due to the reduction in size of rachis.	Produced nearly similar symptoms on <i>Datura stramonium</i> L. and <i>Nicotiana glutinosa</i> L. but on <i>Nicotiana rustica</i> L. symptom of leaf curl was mild and thickening of veins was not so prominent as in the case of specimen A.
C	The same as described for specimen A.	Nearly the same as described for specimen A.
D	The leaves developed vein clearing along with mild curling resulting in yellow mottle in the interveinal region. Later the severely infected leaves showed pale yellow mosaic with prominent upward rolling of leaves (Fig. 3D).	Produced nearly similar symptoms on <i>Datura stramonium</i> L. and <i>Nicotiana glutinosa</i> L. but on <i>N. rustica</i> the symptom of leaf curl was more intense than that of specimen A with clear enations.
E	The same as described for specimen B. (Fig. 3E).	Nearly the same as described for specimen B.
F	The same as described for specimen A.	Nearly the same as described for specimen A.
G	The same as on the sample variety Bombay Best.	On <i>Nicotiana rustica</i> L., <i>N. tabacum</i> L., <i>Datura stramonium</i> L., <i>Solanum melongena</i> L. and <i>Dolichos lablab</i> L. produced nearly similar symptoms as described by Hill (1943).

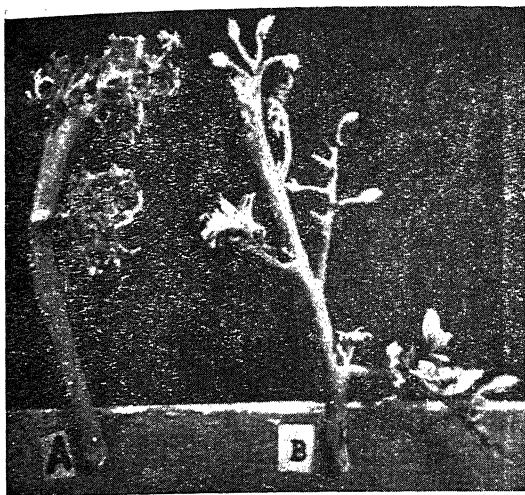


Fig. 1A. A branch from an infected plant of var. Bombay Best showing late symptoms of Big Bud disease of the Tomato.

B. An affected fruit truss showing thickened pedicel and abnormal flowers.

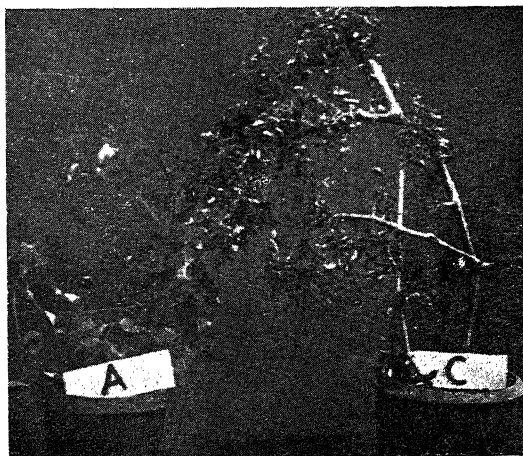


Fig. 2A. It is depicting symptoms of strain A of leaf curl virus on variety Prosperity grafted with specimen A.

C. A diseased plant of variety Marglobe showing field symptoms of strain A of leaf curl virus.



Fig. 3D. Showing symptoms of strain D of leaf curl virus on var. Prosperity of tomato grafted with specimen D.

E. Showing symptoms of strain B of leaf curl virus on var. Prosperity grafted with specimen E.



The results of transmission indicate that the disease of specimens A, B, C, D, E, and F is transmitted to variety Prosperity of tomato by grafting. This establishes the virus nature of the disease. The virus was also transmitted to *Datura stramonium* L., *Nicotiana rustica* L. and the *N. glutinosa* L. and the symptoms produced resembled very closely to those described by Vasudeva and Samraj (1948) for the leaf curl virus of tomato. The negative mechanical transmission, the positive transmission by white flies (*Bemisia tabaci* Gen.) and the symptoms on differential hosts confirm that the virus in the above samples is the leaf curl of tomato or *Nicotiana virus* 10. Further the specimens A, C and F produced nearly similar symptoms on variety Prosperity of tomato. Similarly specimens B and E produced alike symptoms on the aforesaid variety of tomato but different from those produced by specimens A, C and F. The specimen D produced similar symptoms on its sample variety as well as on the test variety Prosperity but differed in its symptom picture from those of specimens A or C or F and B or E. These findings indicate that the specimens A or C or F, B or E and D were infected with different strains of the leaf curl virus. This was also confirmed by the differing reaction on *Nicotiana rustica* L. and cross-protection tests.

The characteristic symptoms of specimen G, positive transmission by grafting and dodder, failure of transmission by white flies (*Bemisia tabaci* Gen.) and mechanical inoculation and reaction on differential hosts indicated that specimen G was affected with Big Bud virus disease of tomato caused by *Lycopersicum virus* 5, Smith (1937).

### Discussion :

From a series of elucidations and results it is elicited that in tomato crop a constellation of virus-like symptoms occur in Kanpur locality. Specimens A, B, C, D, E and F differed mainly in their symptoms on their host varieties in the field. The tests of transmission by graft and white flies (*Bemisia tabaci* Gen.) and their reactions on the differential hosts viz., *Datura stramonium* L., *Nicotiana rustica* L. var. N. P. 25 and *N. glutinosa* L. have however, proved all these symptom types to be of virus origin caused by the same virus (the leaf curl virus of tomato or *Nicotiana virus* (10). This is in agreement with results of Pruthi and Samuel (1941), Bertus (1943) and Vasudeva and Samraj (1948). The differences in symptoms can be explained either due to effect of the virus on varieties of host plants or the strains of the virus occurring in nature. Specimens A or C or F and B or E and the sample D differed in the symptoms produced by them on tomato variety Prosperity and *Nicotiana rustica* L., so much that they have been regarded as different strains of the leaf curl virus. This was also confirmed by cross-protection tests. On the basis of reaction on variety Prosperity of tomato, the strains infecting specimens A or C or F, specimens B or E and D have been designated as 'strain A' or 'typical strain', 'strain B' or 'severe strain' and strain C or 'golden yellow mottle strain' respectively. According to the classification of Smith the aforesaid strains will be designated as *Nicotiana virus* 10 A, B and C. respectively.

Specimen G on the basis of its characteristic symptoms produced on the stem and the flowers of affected tomato plants, transmission of disease only by grafting and dodder and the reaction on differential hosts has been identified as Big Bud virus disease of tomato, caused by *Lycopersicum virus* 5, Smith (1937). These findings are in agreement with results of Samuel *et al* (1933), Michailova (1935), Dana (1940), Hill (1943) and Vasudeva and Lal (1944).

### Summary :

Seven specimens of tomato plants showing virus-like symptoms, collected from different localities in Kanpur, were tested for diagnosis of disease and identification of causal virus. Two new naturally occurring strains of leaf curl virus have been established in addition to the 'typical strain' described by Vasudeva and Samraj (1948). Besides, this is the first report of transmission of Big Bud disease of tomato by dodder and of its occurrence in a severe form in nature from India.

The symptoms characterizing specimen A were leaf curl with green vein banding and reduction in size of terminal leaflets. The disease though transmitted by graft was not mechanically inoculable. Insect vector was white fly (*Bemisia tabaci* Gen.) On *Datura stramonium* L., *Nicotiana rustica* L. and *N. glutinosa* L. the virus produced characteristic symptoms. It has been identified as a strain of *Nicotiana virus* 10 and is similar to specimen C and F. This strain has been designated as *Nicotiana virus* 10 A or 'typical strain' of the leaf curl virus.

Specimen B exhibited slight leaf curl, twisting of leaflets but not pronounced reduction in size of leaves. On the basis of transmission tests and differential host studies it was also identified as probable strain of tomato leaf curl virus. This strain has been found similar to specimen E. This strain has been called *Nicotiana virus* 10 B or 'severe strain' of leaf curl virus.

The symptoms produced by the tomato plants of specimen D consisted of leaf curl with upward rolling of margins and islands of golden yellow colour scattered in the normal green tissue. On the basis of transmission tests and differential host studies it was also identified as a probable strain of leaf curl virus. This strain has been designated as *Nicotiana virus* 10 C or 'Golden yellow mottle strain' of leaf curl virus.

The symptoms characterizing specimen G were, typically erect growth habit with thick stem and pedicels, abnormal flowers with bladder-like calyx, dense rosette-like axillary growth and development of characteristic tissue in association with internal phloem. The disease was transmitted by grafting and dodder but not through sap. White flies (*Bemisia tabaci* Gen.) failed to transmit it. It was successfully transmitted to *Datura stramonium* L., *Nicotiana rustica* L., *N. tabacum* L., *Solanum melongena* L. and *Dalichos lablab* L. The disease has been identified as tomato Big Bud caused by *Lycopersicum virus* 5, Smith (1937).

### Acknowledgement :

Sincere thanks are due to Dr. Babu Singh, Professor of Botany, Government Agricultural College, Kanpur and to Dr. Nandan Singh Bisht, Virologist, Section of the Plant Pathologist to Government, U. P., Kanpur for constructive criticism.

### References :

- Bertus, L. S. Plant Pathology. *Adm. Rep. Dir. Agr., Ceylon*, p. D. 5, 1942. 1943.
- Dana, B. F. Occurrence of Big Bud of Tomato in the Pacific North-West *Phytopathology*, **30** : 866-69, 1940.
- Hill, A. V. Insect transmission and host plants of virescence (Big Bud of Tomato). *J. Coun. Sci. Industr. Res. Aust.*, **16** (2) : 85-90, 1943.
- McClellan, A. P. D. Some leaf curl diseases in South Africa. *Dept. Agri. and For. S. Africa Sci. Bull.*, 225, 1940.

- Michailova, P. V. Pathologico-anatomical changes in the Tomato incident to development of woodiness of the fruit. *Phytopathology*, **25** : 539-58, 1935.
- Pruthi, H. S. and Samuel, C. K. Entomological investigations on the leaf-curl disease of tobacco in Northern India. IV Transmission of the disease by white fly (*Bemisia gossypiperda*) from some new alternate hosts. *India J. agric. Sci.*, **11** : 387-409, 1940.
- Samuel, G., Bald, J. G. and Eardley, C. M. 'Big Bud', a virus disease of the Tomato. *Phytopathology*, **23** : 641-53, 1933.
- Smith, K. M. A text Book of Plant Virus Diseases, Second Edition, J. and A. Churchill, Ltd., London, 1957.
- Storey, H. H. Leaf-curl of Tobacco in Southern Rhodesia. *Rhodesian Agr. J.* **29** (3) : 186-192, 1932.
- Vasudeva, R. S. and Lal, T. B. Big Bud Disease of the Tomato. *Indian J. agric. Sci.*, **14** : 160-162, 1944.
- Vasudeva, R. S. and Samraj, J. A leaf curl disease of Tomato. *Phytopathology*, **38** : 364-369, 1948.

## SOME LEAF SPOT FUNGI

By

HAR PRASAD SRIVASTAVA

Botany Department, University of Allahabad, Allahabad

[Received on 26th September, 1963]

### Introduction :

In spite of considerable importance of leaf spot diseases much attention has not so far been paid towards them. Such diseases reduce the photosynthetic area of the plants which results in slowing the metabolic activities. Severe infections may be responsible for complete defoliations which may ultimately bring the life of entire plant at stake. The diseased leaves also serve as carriers of infection in subsequent years. Special precaution is needed against those organisms which attack fruit trees as they may be responsible for propagation of fruit rot in storage and transit. During the last one year (June 1962--July 1963) a number of leaf spot fungi were collected from several new hosts at Allahabad and its suburbs. The observations are comprised in the present paper. The names of the different hosts have been arranged in alphabetical order.

### Materials and Methods :

The method for taxonomical studies was similar to those suggested by Bilgrami (1963). Diseased leaves were collected from various plants at different intervals. Symptoms were recorded. Slides were prepared by scraping the fruiting bodies produced in the diseased lesions. Isolation were made by cutting small fragments of leaves from the junctions of healthy and infected portions. These pieces were surface sterilized and allowed to grow in culture slants of PDA. Subculturing was carried out from time to time. Morphological characters of the organisms were carefully recorded.

### Records :

Host: *Calotropis gigantea* Br.

Fam. Asclepiadaceae.

The diseased leaves of *C. gigantea* were first observed and collected from Naini in the month of October. They developed gray coloured marginal spot which gradually expanded towards the mid rib. The lesions were usually restricted on either side of it. In later stages the diseased parts manifested shrunken areas. Detachment of the leaves or defoliation was never accomplished. The causal pathogen was identified as *Curvularia pallescens* Boedijn having the following morphological characters :

Hyphae hyaline, branched, septate,  $2.8-3.2\mu$  wide ; conidiophores erect, unbranched, variable in size,  $3.0-3.5\mu$  wide ; conidia straight or very minutely curved (Plate I, Fig. 1), olive green, four celled, middle cells slightly darker in colour and larger than the other cells, end cells colourless and crucible shaped, size ranged from  $21-36 \times 6.5-12\mu$  (average  $31.5 \times 10.5\mu$ ).



Fig. 1. Microphotograph of conidiophore and conidia of *Curvularia pallescens* X550.



Fig. 2. Microphotograph of perithecium and asci of *Thielavia terricola* X350



Fig. 3. Microphotograph of the synnemata of *Malustela aerea*.



Fig. 3a. Microphotograph of L. S. of the synnemata of *Malustela aerea* X350.

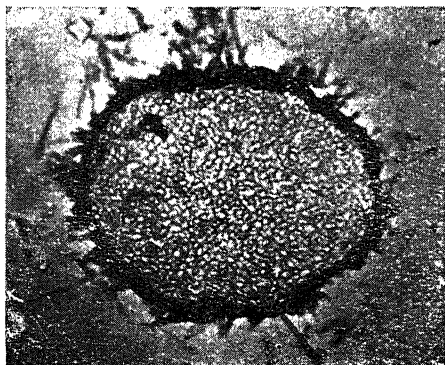


Fig. 3b. Microphotograph of the T. S. of synnemata of *Malustela aerea* X350.

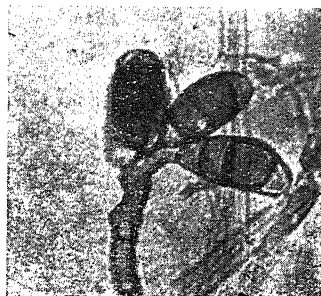


Fig. 3c. Microphotograph of the conidiophore and conidia of *Malustela aerea* X550.

PLATE II



Fig. 1. Microphotograph of mature spores of *Botryodiplodia theobromae* X550.

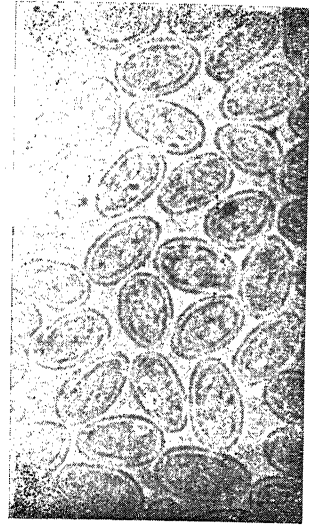


Fig. 2. Microphotograph of young spores of *Botryodiplodia theobromae* X550.

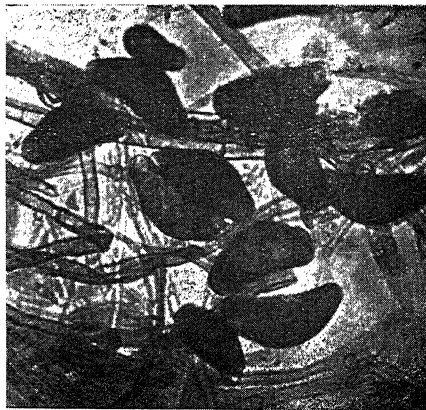


Fig. 3. Microphotograph of spores of *Curvularia siddiquii* X500.

PLATE III

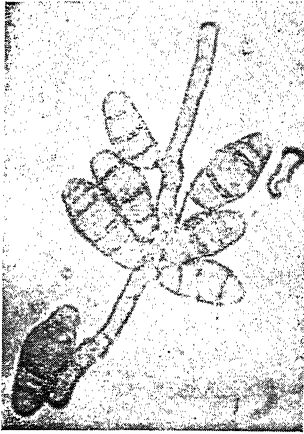


Fig. 1. Microphotograph of conidiophore and conidia of *Curvularia fallax* X550.



Fig. 2. Microphotograph of conidiophore and conidia of *Curvularia verruculosa* X600.

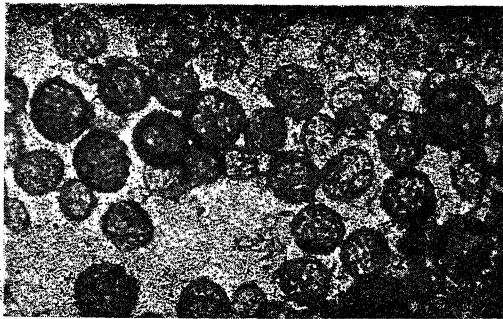


Fig. 3. Microphotograph of spores of *Epicoccum nigrum* X550.

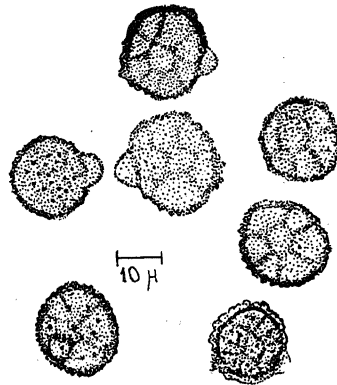


Fig. 4. Camera lucida sketch of spores of *Epicoccum nigrum*.

PLATE IV



Fig. 1. Microphotograph of conidia of *Torula herbarum* X550.

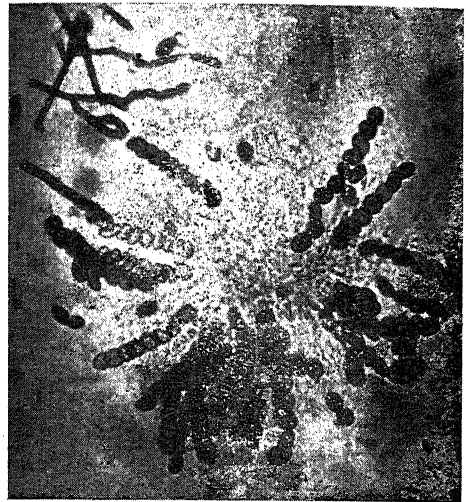


Fig. 2a. Microphotograph of ruptured perithecium of *Ascotricha chartarum* X550, showing asci and ascospores.

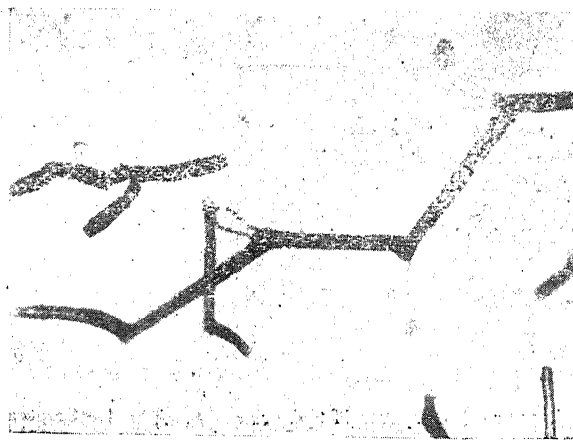


Fig. 2b. Microphotograph of terminal hairs of perithecium of *Ascotricha chartarum* X600.

Locality : Naini.

This is the first record of *C. pallescens* on this host. The culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Dahlia variabilis* Desf.

Fam. Compositae.

A large number of *D. variabilis* plants growing in the Botanical Gardens of Allahabad University, exhibited brown coloured spot during the months of December and January. Scattered lesions of various shapes and sizes were developed over the entire lamina. In initial stages the spots were faint and dot like and ultimately they assumed big, irregular, dark brown areas. Older lesions collapsed and got detached from the living portions of the leaves. Defoliation was not noticed. Black fruting bodies were occasionally perceptible on the diseased regions. Isolations from the infected parts yielded *Thielavia terricola* (Gilman and Abbot) Emmons, in culture having following morphological characters :

Hyphae hyaline, branched, septate,  $2.0-4.5\mu$  wide ; cleistothecia oval, without appendages (Plate I, Fig. 2), cleistothecial wall brown, composed of pseudoparenchymatous cells, size ranged from 78 to  $126\mu$  in diameter ; asci small, hyaline or olive green, pyriform having 8 ascospores without any particular arrangement, deliquescing inside the cleistothecium, measuring  $23-30 \times 14-17\mu$  ; ascospores small, olive green or light brown, fusiform or elliptical, measuring  $8.0-14.0 \times 6.0-7.5\mu$ .

Locality : Botanical Gardens of Allahabad University.

This is the first record of *T. terricola* on the leaves of *D. variabilis*. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

Associated with above leaf spot, another organism which was identified as *Malustela aerea* Batista, Lima and Vasconcelos was also isolated. The cultural growth of the fungus was very peculiar due to the presence of very much elongated synnemata (Plate I, Fig. 3) covered with conidiophores, and vegetative hyphae. The wall of synnemata was pseudoparenchymatous (Plate I, Fig. 3a and 3b) ; conidiophores and conidia were quite similar to those of *Curvularia* (Plate I, Fig. 3c). Due to the presence of synnemata, Batista *et al.* (1960), erected the genus *Malustela* under family Stilbaceae. The fungus has following morphological characters :

Hyphae hyaline, branched, septate,  $2.5-3.0\mu$  wide ; synnemata very much elongated, branched, covered with conidiophores and conidia, and measuring  $2150-4500 \times 150-290\mu$  ; conidiophores olive green, unbranched, septate, very much elongated,  $3.0-3.5\mu$  wide ; conidia large, curved 2 to 3 septate with crucible shaped end cells, two middle cells larger and slightly darker than the others,  $16.5-29.0 \times 8.0-12.5\mu$  (average  $22.5 \times 10.5\mu$ ).

Locality : Botanical Gardens of Allahabad University.

This is the first record of *Malustela* on the above host and from India. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Ficus bengalensis* L.

Fam. Moraceae.

Leaves of *F. bengalensis* having brown spots surrounded by a black band were collected from Suhagi, about 35 miles south of Allahabad, in the month of September. There was no consistency regarding the shape and size of the spots

and they were found scattered all over the leaf. In the early stages of infection, the leaves showed discoloration of diseased areas which later assumed brown colour. Black small fruiting bodies were quite evident on both the surfaces of the lesions. Separation of infected parts was quite common. The organism was identified as *Bartalinia robillardoides* Tassi having the following morphological characters :

Hyphae white, branched, septate ; pycnidia ostiolate, black and rounded 95—175 $\mu$  in diameter ; conidiophores short, unbranched ; conidia hyaline or olive green, straight or very slightly bent, three septate, apical cell with three delicate appendages while lower cell tapers also into a hyaline appendage, 18.0—22.5  $\times$  6.0—8.5 $\mu$  (average 21.2  $\times$  7.6 $\mu$ ).

Locality : Suhagi

This organism has been recorded for the first time on this host. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Mimusops elangi* L.

Fam. Sapotaceae.

Leaves of *M. elangi* manifested severe leaf spotting in October. In early stages light brown spots were produced on the margins of the leaves, which gradually advanced towards the mid rib and sometimes covered the entire lamina. The diseased spots were surrounded by an ash coloured band. Fructifications of the organism were perceptible on the upper surface only. Detachment of diseased parts was observed. Defoliation was quite consistent. Isolate responsible for the disease was identified as *Botryodiplodia theobromae* Pat. having following morphological characters :

Hyphae brown, branched, closely septate, 3.0—5.0 $\mu$  wide ; stroma black, with numerous locules, pear shaped or globose ; conidiophores short, 7.0  $\times$  2.3 $\mu$  ; young conidia single celled (Plate II, Fig. 2), hyaline ; mature conidia bicelled (Plate II, Fig. 1), dark brown, having striations over the conidial wall, 21.0—30.0  $\times$  10.0—14.5 $\mu$  (average 26.2  $\times$  12.5 $\mu$ ).

Locality : Khusrubagh and University Campus.

This is a new record of *B. theobromae* on this host. Culture is deposited in Botany Department, University of Allahabad.

*Psidium guajava* L.

Fam. Myrtaceae.

Dark brown spots were observed on the leaves of *P. guajava* in the month of September—October. The infection was restricted only on the tips and margins in the initial stages but subsequently the spots covered the whole of the leaf lamina. Defoliation was observed in case of severe infections. The organism isolated from such leaves was identified as *Curvularia siddiquii* Ahmed et Quraishi having following morphological characters :

Hyphae white or olive green, septate, branched, 3.0—4.0 $\mu$  wide ; conidiophores light brown, variable in size, unbranched, septate, 3.5—4.5 $\mu$  wide ; conidia large, brown, curved, four celled, two inner cells bigger than the distal cells (Plate II, Fig. 3), 27.5—39.0  $\times$  13.5—21.0 $\mu$  (average 33.0  $\times$  16.5 $\mu$ ).

Locality : Naini and University Farm.

This is the first record of *C. siddiquii* from India as well as on this host. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Livistona rotundifolia* L.

Fam. Palmae.

Leaves of *L. rotundifolia* were observed to be severely infected in the month of November. Gray coloured spots of various shapes were seen on the leaves. In the beginning, the leaves manifested discoloration at places, which in advanced stages enlarged considerably and assumed dark gray colour. In severely infected leaves, detachment of diseased portion was consistent, without any apparent sign of defoliation. Isolations from such spots yielded *Curvularia fallax* Boedijn, having following morphological characters :

Hyphae hyaline, branched, septate,  $2.5-3.5\mu$  wide ; conidiophore variable in length, sometimes very long, septate ; conidia curved, 3 to 4. septate, two inner cells bigger and darker than the other cells (Plate III, Fig. 1),  $14.5-27.5 \times 7.5-11.5\mu$  (average  $19.5 \times 9.5\mu$ ).

Locality : Naini and Dandi village.

This is the first record of *C. fallax* on the above host and also first report from India. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Punica granatam* L.

Fam. Punicaceae.

Leaves of *P. granatum* manifested a severe leaf spot disease in the month of December. The dark brown spots surrounded by blackish band were either marginal or scattered. The diseased areas generally remained attached to the healthy parts of the leaf. Defoliation of severely infected leaves was common. Isolations from such spots yielded *Curvularia verruculosa* Tandon et Bilgrami in culture. Character of the fungus was as follows :

Hyphae hyaline, branched, septate,  $3.0-3.5\mu$  wide ; conidiophore erect, septate, variable in length,  $3.5-4.0\mu$  wide ; conidia straight or slightly curved, four celled, with verruculose wall, (Plate III, Fig. 2), second cell from tip was larger than the others,  $24.0-36.0 \times 9.0-13.5\mu$  (average  $31.4 \times 11.8\mu$ ).

Locality : Alfred Park and Naini.

This is a new record of *C. verruculosa* on the above host. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Rauwolfia serpentina* Benth.

Fam. Apocynaceae.

The diseased leaves of *R. serpentina* were collected in the month of February. The leaves manifested dark brown marginal spots which gradually advanced towards the mid rib and in some cases even crossed it and covered the entire lamina. Fruiting bodies were not observed on the diseased lesions. Separation of diseased portions or defoliation was quite consistent. The isolate sporulated profusely in culture. It was identified as *Epicoccum nigrum* Link. having the following morphological characters :

Hyphae hyaline, septate, branched,  $3.0-3.5\mu$  wide ; sporodochia small, scattered ; conidiophores small, septate, conidia dark brown or black, wrinkled, globose, one to many celled, verrucose, (Plate II, Fig. 3),  $20.0-25.8\mu$  in diameter.

Locality : Rajapur and Botanical Gardens, Allahabad.

This is a new record of *E. nigrum* on the above host. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

*Sansevieria macrophylla* Thunb.

Fam. Liliaceae.

It was observed in the month of July that leaves of *S. macrophylla*, growing in Botanical Gardens of University of Allahabad, showed gray coloured spots. The spots were either marginal or at the tips, which gradually proceeded towards the centre. In the beginning, the leaves showed discoloration of infected regions which ultimately turned gray. In severely infected leaves the diseased parts were fully dried and they got detached from the healthy portions. On both the sides of the leaves small black bodies were visible which were identified as perithecia of *Ascotricha chartarum* Berk. having the following morphological characters :

Hyphae black, septate, branched,  $1.5-2.0\mu$  wide ; conidiophores black, branched, tips hyaline ; conidia pear shaped, olive green,  $4.0-6.0 \times 3.0-4.0\mu$  ; perithecia globose, black, with rounded base and a neck above, covered with black hairs, terminal hairs arising from the neck region possessed characteristic ampullae (Plate IV, Fig. 2b)  $1.5-3.5\mu$  wide and  $500-600\mu$  in length ; asci hyaline cylindrical, 8-spored (Plate IV, Fig. 2a),  $27.0-36.0 \times 6.0-9.0\mu$  ; ascospores arranged in a row, ovoid, brown,  $4.5-7.5 \times 3.0-4.5\mu$ .

Locality : Botanical Gardens, Allahabad University.

This is a new record of *A. chartarum* on this host and also a new report from India. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

A black mass of spores was seen on some dried and infected leaves of *S. macrophylla*. This saprophytic fungus was identified as *Torula herbarum* (Pers.) Link ex Fr. In culture the fungus showed the following morphological characters :

Hyphae hyaline, branched, septate,  $2.0-3.0\mu$  wide ; conidia dark brown, thick walled (Plate IV, Fig. 1), two to four celled, straight, arranged in chains, cells at the end of the chains were oval and faint in colour,  $7.5-13.0 \times 3.0-6.0\mu$  (average  $10.5 \times 4.5\mu$ ).

Locality : Botanical Gardens, Allahabad University.

This is a new record of *T. herbarum* on the above host. Culture is deposited in C. M. I., Kew, and Botany Department, University of Allahabad.

**Summary :**

The present paper comprises the taxonomical studies of the following fungal organisms which have been recorded on the leaves of new hosts : *Curvularia pallescens* from *Calotropis gigantea*, *Thielavia terricola* and *Malustela aerea* from *Dahlia variabilis*, *Bartalinia robillardoides* from *Ficus bengalensis*, *Botryodiplodia theobromae* from *Mimusops elangi*, *Curvularia siddiquii* from *Psidium guajava*, *Curvularia fallax* from *Livistona rotundifolia*, *Ascotricha chartarum* and *Torula herbarum* from *Sansevieria macrophylla*.

**Acknowledgements :**

The author is grateful to Dr. K. S. Bilgrami for suggesting the outline of the work, critically examining the manuscript and constantly giving the encouragement. He is also indebted to Professor R. N. Tondon for providing Laboratory facilities and to Dr. J. C. F. Hopkins, Director, C. M. I., Kew, for identifying some of the isolates.

**References :**

- Batista, A. Chaves, J. Americo de Lima and C. T. de Vasconcelos. "Dois novos deuteromycetes do ar atmosferico". *Universidade do Recife*. Pub. No. 263, 1960.
- Bilgrami, K. S. Leaf spot diseases of some common ornamental plants. *Proc. Natl. Acad. Sci.*, **33** : 429-452, 1963.

# EFFECT OF GIBBERELIC ACID ON ZYGNEMA SPP.

By

BRAJ NANDAN PRASAD

*Department of Botany, Lucknow University, Lucknow (India)*

[Received on 26th November, 1963]

The effect of Gibberellic acid and gibberellins on angiosperms has been seen by many workers (*cf.* Brian and Hemming 1955, Radley 1956 and Brian and Grove 1957) and it has been established that the acid can make a recessive dwarf variety of sweet-pea, garden-pea or maize assume the growth-habit of the tall variety. It has been suggested that these dwarf varieties arose from the respective tall varieties by mutation of a single gene which involves the failure of some step in biosynthesis by which Gibberellic acid or some closely related substance is produced. This contention is strengthened by the fact that substances similar to Gibberellic acid have been found to occur in higher plants (*cf.* Radley, *loc. cit.*).

It is generally believed that the major part of the increase in size due to the effect of Gibberellic acid is produced by a greater elongation of the cells constituting various tissues. Little work, however, has been done to find out its effect on cell-division and, more directly, on nuclear division (Burger, 1957). Further, only one investigation (Burdett and Turnbull, 1960) on the effects of Gibberellic acid on an alga (*Chlamydomonas*) has been attempted so far. Thus, it was felt desirable to investigate the two aspects mentioned above.

Two species of *Zygnema*, *Z. cruciatum* and "Z. 5" were chosen for the study. The former species was kept in culture solutions of Godward's inorganic medium (Godward, 1942) fortified with soil-extract, containing Gibberellic acid in proportions of 100, 50, 10 and 1 parts per million respectively; the latter species was similarly kept in 50 p.p.m., 10 p.p.m. and 1 p.p.m. solutions in a culture cabinet receiving 16 hours light and 8 hours darkness. Controls, without any addition of the Gibberellic acid were set up under the same conditions. A similar set of controls and cultures containing Gibberellic acid was placed in continuous light.

Fixations were made in 1 : 3 acetic-alcohol at the end of 24, 48 and 72 hours from each culture placed under conditions of alternating dark and light periods, and, after 48 hours only from the materials placed in continuous illumination. The number of dividing nuclei per 1000 nuclei was counted in each case. It was found that divisions took place at a rate slower than that of the control in 1 p.p.m. samples of both species fixed after 24 hours of treatment. In all higher concentrations of Gibberellic acid, divisions had completely stopped in both species. Even in the 1 p.p.m. sample, no division was found in the fixations made after 48 and 72 hours.

In the materials placed in continuous light and fixed after 48 hours, it was found that no divisions took place in "Z. 5" species in any concentration of Gibberellic acid; *Z. cruciatum*, however, showed two early prophases and one telophase in the 1 p.p.m. sample. No cytological abnormality was observed in any of the stages seen although, it must be pointed out that the number of dividing nuclei seen is too small to draw any conclusions on this important aspect.

At the end of 48 hours, it was noticed that all the materials had lost their fresh green colour and appeared pale or yellow-green. As such, some material from each culture was removed, washed and inoculated in standard culture medium not containing any Gibberellic acid. At the end of a week, it was found that the inoculum of "Z. 5" from the 50 p. p. m. Gibberellic acid sample had died while those from 10 p.p.m. and 1 p.p.m. samples recovered and could grow again. Of *Z. cruciatum*, it was found that only the inoculum from the 1 p.p.m. culture could survive and all the higher concentrations of Gibberellic acid proved lethal.

All the cultures left in the media containing Gibberellic acid in various concentrations were likewise found to have been killed.

It would appear from the above work that Gibberellic acid in very small concentrations inhibits nuclear division in species of *Zygnema* and in even slightly higher concentrations (10 p.p.m. or more), has a poisonous effect and the plants are killed.

No increase in the size of cells was found in either of the two species under investigation and therefore, the genetic effect noticed in sweet-pea, garden-pea, maize etc. (cf. Brian and Grove, 1957) could not be produced here.

#### References :

- Berger, C. A. Some cytological effects of Gibberellin. *Bull. Torrey Bot. Club*, **84** : 356-360, 1957.
- Brian, P. W. and Grove, F. Gibberellic acid, *Endeavour*, **16** (63) : 161-171, 1957.
- Brian, P. W. and Hemming, H. G. The effect of Gibberellic acid on shoot-growth of pea seedlings. *Physiol. Plant*, **8** : 669-689, 1955.
- Burdett, R. M. and Turnbull, L. P. The effect of Gibberellic acid on the growth of *Chlamydomonas moewusii*. *Gerl. Br. Phycol. Bull.*, **2** (1) : 13, 1960.
- Godward, M. B. E. The Life-cycle of *Stigeoclonium amoenum* Kütz. *New Phytol.*, **41** : 293-301, 1942.
- Radley, M. Occurrence of substances similar to Gibberellic acid in higher plants. *Nature*, **178** : 1070-1071, 1956.

INFLUENCE OF PRE-SOAKING *VIGNA CATJANG* (VAR. RUSSIAN  
MAMMOTH) SEEDS IN AQUEOUS SOLUTIONS OF POTASSIUM  
GIBBERELLATE ON ITS SUBSEQUENT GROWTH,  
METABOLISM, RESISTANCE TO DROUGHT  
AND NODULATION

By

AMAR SINGH, O. S. SINGH and P. N. SINGH

*Department of Botany, University of Allahabad, Allahabad*

[Received on 28th October, 1963]

**Introduction :**

The influence of gibberellin on germination, growth, metabolism and yield of crop plants, has been studied by many (Hayashi, 1940 ; Brian *et al*, 1954 ; Marth *et al*, 1956 ; Wittwer and Bukovac, 1957 ; Gray, 1957 ; Singh, 1963). Aqueous solution of gibberellin was used for seed-treatment to assess the effect on plants by Hayashi, 1940 ; Wittwer and Bukovac, 1957 ; Anony, 1957 ; Eagle and Bird, 1958 ; Sandhu and Husain, 1961. They recorded improved germination, rapid emergence and taller seedlings, increase in length of hypocotyle and also internodes of plants.

Thruber *et al* (1958), and Fletcher *et al* (1959), have registered a reduction in nodule formation in leguminous plants by gibberellin treatment. Radley, 1961 ; suggested that the nodule inhibiting factor was possibly a *gigibberellin* in leguminous plants.

Investigations were conducted to elucidate the influence of gibberellic acid applied as seed-treatment on growth, metabolism and nodulation of *Vigna catjang*.

**Method and Materials :**

Seeds of cow-pea (*Vigna catjang*, var. Russian mammoth), of uniform size and weight were soaked for eight hours in aqueous solutions of 10, 100, 200 and 400 ppm of potassium gibberellate containing 0.88 per cent of gibberellic acid. Seeds treated with distilled water served as control. Eight seeds for each treatment were sown in asphalt coated earthen pots containing acid leached sand (Hewitt, 1947).

On germination, seedlings were thinned to five per pot. Hoagland's complete nutrient solution was applied at weekly intervals starting from one week after germination. With the first application of nutrient solution, pots were inoculated with water extract of nodules of cow-pea plant grown separately.

Plants were removed at 40-day age and the roots washed by a fine jet of water over wire gauze to remove all sand and collect the broken roots if any. Linear growth upto the apex of the leaf, maximum length of stem upto the stem tip, internodal elongation, leaf area and root length were measured. Plants were fractioned into roots, nodule, stem and leaf and their quantitative growth were recorded.

The capacity to resist drought was evaluated by measuring chlorophyll stability index after the method of Kaloyereas (1958).

The leaves were immersed in water and heated gradually in a temperature regulated water bath till a temperature reached beyond which chlorophyll destruction proceeded rapidly. The critical temperature proved to be between 56°C – 57°C. A 5 g. sample of leaf from each treatment was placed in a tube one inch in diameter with 50 cc. of distilled water and heated at  $56^{\circ} \pm 1^{\circ}\text{C}$  for exactly half an hour. The leaves were then ground in a blender for five minutes with 100 cc. of 80% acetone solution in water. The chlorophyll-extract was filtered and the filtrate examined immediately for light absorption with a Klett Photoelectric Colorimeter using red filter (No. 66). Pigment was also extracted from a 5 g. sample of unheated leaves and its light absorption measured. The difference between the two values was taken to denote the "Chlorophyll Stability Index" referred to as CSI in the text.

Transpiration rate was measured by inserting the entire root of plant in 50 cc. conical flasks containing distilled water. The rate of evaporation was determined by maintaining one series of five conical flasks without plant to serve as control. Total nitrogen was determined by Kjeldahl's method (A. O. A. C., 1950) and total carbohydrate by the method of Loomis and Shull (1937).

The data were analysed for variance by Fisher's method (1950).

## Results :

### *Qualitative expression of growth :*

*Linear growth of tops :* Average linear growth of tops increased significantly by all the concentrations of gibberellic acid (Table 1). Lower dose of 10 ppm exhibited maximum increase in height. Higher concentration of 400 ppm though superior to control, recorded a lower value than in 10 ppm application. The 100, 200 and 400 ppm doses did not vary significantly in effectiveness amongst themselves.

TABLE 1  
Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on its subsequent growth

Treatments	Linear growth (cm.)	Stem length (cm.)	Root length (cm.)	Leaf expansion (sq. cm./plant)	Single leaf expansion (sq. cm.)
Control	47.54	30.40	33.63	429.15	34.33
10 ppm	58.16	35.60	30.47	435.75	33.48
100 ppm	56.42	38.70	28.65	358.09	32.92
200 ppm	54.17	34.92	29.38	366.80	28.65
400 ppm	53.90	33.20	26.42	342.00	27.05
S. E.	1.46	1.70	1.53	5.32	0.19
C. D. at 5%	3.18	3.70	3.33	11.59	0.42
C. D. at 1%	4.46	5.10	4.67	16.25	0.60

*Linear growth of stem* : Gibberellic acid at 100 ppm. proved optimum for elongation of stem (Table 1). Higher doses of 200 and 400 ppm proved less effective than other concentrations and varied little in significance amongst themselves.

*Linear growth of root* : A marked reduction in root length was noticed ; this reduction increased with increase in the concentration (Table 1). Concentrations of 100 and 200 ppm were equally effective, while 400 ppm decreased the root length to the maximum extent.

*Leaf expansion* : Average expansion of foliage decreased significantly so also that of a single leaf with gibberellic acid application. Higher concentration of 400 ppm decreased both the average leaf area of a plant as well as of single leaf to the maximum extent (Table 1). The effectiveness of gibberellic acid in reduction of leaf expansion/plant was highly significant amongst the concentrations except between 10 and 400 ppm on the one hand and 100 and 200 ppm on the other. A highly significant value amongst the various concentrations was recorded for reduction in average expansion of single leaf (Table 1).

*Internodal elongation* : Maximum elongation of the basal internode was obtained by 10 ppm concentration followed by 400 and 100 ppm in sequence. Aqueous solution of gibberellic acid applied at the rate of 400 ppm brought about maximum elongation of second internode but concentrations remained non-significant amongst themselves. The 100 ppm dose was significantly superior to other treatments in increasing the length of 3rd, 4th and 5th internodes. The third and fourth internodes increased significantly under the effect of treatments irrespective of the concentrations. Gibberellic acid at the concentration of 400 ppm was negatively significant for the elongation of the 5th internode.

TABLE 2

Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on the linear growth of successive internodes

(cm.)

Treatments	Base				Apex
	1st	2nd	3rd	4th	5th
Control	2.80	2.82	2.91	2.32	2.52
10 ppm	3.70	4.28	4.10	3.60	3.92
100 ppm	3.16	4.38	4.30	3.88	4.08
200 ppm	2.51	4.78	3.26	3.04	2.92
400 ppm	3.50	4.94	3.18	3.42	1.94
S. E.	0.36	0.26	0.32	0.29	0.15
C. D. at 5%	0.77	0.56	0.68	0.62	0.33
C. D. at 1%	1.06	0.78	0.94	0.86	0.42

*Quantitative expression of growth* :

*Root* : A marked reduction in fresh weight of light-avoiding parts of the plant under each treatment was recorded (Table 3). 400 ppm. concentration of

gibberellic acid was found to be the most deleterious dose in depressing the fresh weight of root. Concentrations of 100 and 200 ppm were non-significant between themselves in their effectiveness. The application of gibberellic acid reduced dry matter accumulation in root markedly and significantly. The concentration of 200 ppm brought about maximum reduction while the effect of 10 ppm was minimum (Table 4)

TABLE 3  
Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on its subsequent growth  
(Fresh weight, g/plant)

Treatments	Root	Stem	Leaf	Shoot/Root
Control	12.00	4.22	12.23	3.00
10 ppm	8.07	5.02	9.84	3.01
100 ppm	7.10	5.27	8.38	3.38
200 ppm	7.13	4.73	9.93	4.72
400 ppm	6.59	4.31	8.77	3.55
S. E.	0.15	0.10	0.26	0.24
C. D. at 5%	0.32	0.22	0.56	0.52
C. D. at 1%	0.44	0.30	0.77	0.73

*Stem*: Unlike the deleterious effect on root growth, gibberellic acid increased significantly both fresh and dry weight of light-loving parts of the plant (shoots). The concentration of 10 ppm proved optimum for fresh weight. Except 400 ppm all other concentrations were highly significant and also amongst themselves (Table 3). 100 ppm was again superior for maximum accumulation of dry matter but 400 ppm which was non-significant for fresh weight took the second position (Table 4).

TABLE 4  
Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on its subsequent growth  
Dry weight g/plant

Treatments	Root	Stem	Leaf	Shoot/Root
Control	0.820	0.726	1.742	1.372
10 ppm	0.700	0.720	1.385	1.715
100 ppm	0.644	0.870	1.317	1.923
200 ppm	0.460	0.754	1.423	2.054
400 ppm	0.572	0.761	1.276	1.983
S. E.	0.031	0.022	0.039	0.018
C. D. at 5%	0.065	0.047	0.83	0.039
C. D. at 1%	0.090	0.066	0.115	0.055

**Leaf:** The depressive effect of potassium gibberellate on fresh and dry weight of leaves was highly significant. 100 ppm dose of gibberellic acid brought about the maximum reduction in fresh weight of leaves (Table 3) and 400 ppm in its dry weight (Table 4). 10 ppm and 100 ppm concentrations were non-significant for dry matter accumulation in leaf. All other doses of the gibberellic acid proved negatively significant.

**Shoot/Root Ratio:** It increased significantly on fresh as well as dry weight basis, with increase in the concentration of gibberellic acid. 200 ppm and 400 ppm doses showed maximum ratio, the former surpassed the latter in this respect (Table 3 and 4).

**Carbohydrate Content:** 400 ppm concentration of gibberellic acid brought about maximum increase in carbohydrate content of leaf followed by 200, 10, 100 ppm doses in succession. Control plants possessed minimum quantity (Table 5). A significant decrease in carbohydrate content altered by treatment concentration was registered both in stem and root in comparison to control (Table 5); 400 ppm decreased it to maximum extent in both the parts. 10 ppm was non-significant in its effect in carbohydrate accumulation over control in stem though positively significant in increasing it in root.

TABLE 5

Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on carbohydrate and nitrogen content

Treatments	Percent carbohydrate			Percent nitrogen		
	Leaf	Stem	Root	Leaf	Stem	Root
Control	2.050	3.256	1.261	4.806	2.516	1.456
10 ppm	2.412	3.241	1.305	4.725	2.313	1.215
100 ppm	2.313	2.852	1.153	4.406	2.365	1.317
200 ppm	2.526	2.905	1.204	4.513	2.218	1.282
400 ppm	2.643	2.803	0.953	4.207	2.102	1.268
S. E.	0.008	0.014	0.042	0.098	0.035	0.007
C. D. at 5%	0.017	0.030	0.091	0.213	0.076	0.015
C. D. at 1%	0.024	0.042	0.118	0.299	0.106	0.021

**Nitrogen content:** A marked decrease in total nitrogen content was recorded in all parts of the plant (Table 5). 400 ppm caused maximum reduction in nitrogen content of leaf and stem though not of root. In general, treatments were significant in reducing the total nitrogen content in all parts but in few instances only these were significant amongst themselves (Table 5).

**Nodulation:** Lower concentrations of gibberellic acid viz., 10 ppm and 100 ppm reduced average nodule number of a plant significantly but higher concentrations of 200 and 400 ppm increased it significantly (Table 6). Maximum nodule count was recorded in 200 ppm concentration.

TABLE 6

Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on nodulation, nodule development and Root/nodule ratio

Treatments	Count/ plant	Fresh wt. g/plant	Dry/wt. g/plant	Root : Nodule (Fresh wt. basis)	Root : Nodule (Dry wt. basis)
Control	22	0.936	0.123	12.90	6.67
10 ppm	13	0.735	0.114	11.05	4.02
100 ppm	16	0.872	0.120	8.16	5.36
200 ppm	32	0.658	0.104	10.90	6.74
400 ppm	28	0.661	0.102	9.80	5.60
S. E.	1.7	0.057	0.002	0.29	0.24
C. D. at 5%	3.6	0.121	0.004	0.63	0.52
C. D. at 1%	4.9	0.166	0.006	0.88	0.73

*Nodular development* : Gibberellic acid at all the concentrations, was significant in lowering the fresh as well as dry weight of nodule (Table 6). Higher concentrations of 200 ppm and 400 ppm were equally effective since there was non-significant difference between these two. Likewise, there was also non-significant difference between control and 10 ppm level in the nodular development.

*Root/Nodule Ratio* : Application of gibberellic acid was also significant in reducing the root/nodule ratio on fresh as well as dry weight basis (Table 6). The root and nodule development was reduced significantly by all gibberellic acid treatments but nodulation was more in 200 ppm and 400 ppm doses. 10 ppm. concentration was effective in reducing the root/nodule ratio to maximum extent.

TABLE 7

Influence of pre-soaking *Vigna catjang* seeds in aqueous solutions of potassium gibberellate on chlorophyll content, its stability index, photosynthetic efficiency and transpiration

Treatments	Chlorophyll		CSI	Leaf area/dry wt. of leaf (per plant)	Transpiration/ g/100 sq. cm. per hour
	Before heating (micron)	After heating (micron)			
Control	440	444	6	246.64	1.12
10 ppm	390	388	10	331.78	1.23
100 ppm	365	345	20	261.05	1.45
200 ppm	330	290	40	258.32	1.37
400 ppm	315	285	30	281.91	1.85
S. E.	5.21	5.90	3.71	4.79	0.08
C. D. at 5%	11.35	12.85	8.08	10.43	0.17
C. D. at 1%	15.91	18.02	11.33	14.63	0.24

**CSI and Chlorophyll Content :** Highly significant inverse correlation was observed between doses of gibberellic acid and chlorophyll content of leaves. GA at 400 ppm decreased chlorophyll content to the maximum (Table 7). CSI increased with concentration of gibberellic acid resulting in decreased resistance to drought. 200 ppm of GA increased susceptibility to drought to the maximum extent (Table 7).

**Photosynthetic efficiency :** Gibberellic acid treatment decreased dry matter synthesis in leaf. 10 ppm and 400 ppm concentration of gibberellic acid reduced the rate of photosynthetic activity of the leaf (Table 7). 100 ppm and 200 ppm concentration reduced it to a significant extent.

**Transpiration rate :** A significant increase in transpiration rate was obtained with gibberellic acid treatment (except 10 ppm dose, Table 7). Its 400 ppm concentration increased the transpiration rate to the maximum extent. No significant differences were recorded between 10 and 200 ppm on the one hand and 100 and 200 ppm treatments on the other.

### Discussion :

Seed treatment with potassium gibberellate as aqueous solution affected shoot elongation of *Vigna catjang* plant. Such responses have been reported by Brian and others (1954), Singh (1963), Brian and Hemming (1955) and Marth *et al* (1956), with several types of plants by other methods and forms of gibberellic acid application. Elongation of stem was brought about by the summation of individual internode lengths. Basal nodes were maximally affected as was also recorded by Yabuta and Hayashi (1939) and Singh (1963) unlike observations of Marth *et al* (1956) and Brian and associates (1954) that the internode nearer the tip was maximally elongated. As in wheat (Singh, 1963), non-polar movement and auxin-mediated nature of gibberellic acid was evidenced with *Vigna catjang* also.

Stem elongation was associated with reduced root growth and development as has been recorded by Marth *et al* (1956) and Brian *et al* (1960). Brian *et al* (1960) observed that gibberellic acid prevented rooting by a direct local inhibition of cell division in the formation of organised root primordia. Growth and development of the root system was adversely affected by gibberellin treatment in these investigations. [Cf. Table 1 (length), Table 3, (fresh wt.) and Table 4 (dry weight)].

Leaf expansion was restricted by gibberellic acid and this is in conformity with the findings of Yabuta and Hayashi (1939). Brian (1958) and Singh (1963) obtained, with wheat, significant increase in leaf expansion. The response was controlled by concentration and form of gibberellin, nature of crop plant specially with respect to its nitrogen metabolism.

With decrease in leaf expansion a marked decrease in chlorophyll content was recorded as also reported by Marth *et al* (1956). A significant decrease in leaf area and chlorophyll content resulted in reduction of photosynthetic efficiency of leaf (Cf. Table 7 for leaf weight). The total dry matter of the plant also decreased as is evidenced by the summation of the weight of root, stem and leaf.

Seed treatment with gibberellic acid, in present investigations, reduced nitrogen as well as carbohydrate content in different parts of the plant with the possible reduction of hydrophilic colloidal substances in the cells and thereby the viscosity of the protoplasm affecting resistance to drought adversely. The decrease in photosynthetic efficiency also reduced the viscosity of the protoplasm and bound water content to make the plant susceptible to drought. Raheja (1951)

has stated that drought resistant plants have high photosynthetic activity, viscosity of protoplasm and bound water. Higher rate of transpiration observed as a result of application of gibberellic acid, increased the susceptibility to drought (Iljin, 1957). He reported that greater loss of water stimulated the transformation of sugars to starch and lowered the osmotic pressure of the cell sap. The reduction of drought resistance due to significant decrease in nitrogen content in leaf, stem and root finds support in the work of Kesseler (1958) who stated that an intensified RNA synthesis was the cause of drought hardiness. In the present instance significant reduction in nitrogen content was connected with reduced protein synthesis (Mosolov, 1961) so also resistance to drought.

Carbohydrate accumulation in leaves and its reduction in stem and root coupled with a marked decrease in total nitrogen content in all the plant parts by gibberellic acid treatment was also reported by Gopalachari and Naidu (1961), Mosolov (1961) and Sytnyk (1961). Mosolov (1961) believed that the decrease in soluble carbohydrate in stem and roots was related with delay in the movement from the leaves and it also disturbed the amino-acid metabolism. Sytnyk (1961) held that the increased total sugar content together with decrease of protein content may indicate the decrease of carbohydrate expenditure for protein synthesis.

Nodular development too was negatively related with concentration of gibberellic acid. Reduction in nodulation capacity of *Phaseolus* was reported by Thruber *et al* (1958) and in some species of *Trifolium* by Fletcher *et al* (1959) by gibberellic acid treatment. Radley (1961) extracted gibberellin-like substance from the nodules of leguminous plants. Her results suggested that the nodule inhibiting factor produced was probably a gibberellin.

In spite of the direct effect of gibberellic acid on nodular development, indirect effect of growth and also nitrogen and carbohydrate metabolism was reported by several workers with several legumes. Eaton (1931) showed that symbiotic relationship between leguminous plants and nodule bacteria was affected by the carbohydrate content of plants. The increase in carbohydrate content in leaves and reduction in nodular development (as in the present investigations), has been explained by Deats (1925) to be due to higher cell sap concentration in the leaves associated with increased content of reduced sugar of tops.

Greater accumulation of carbohydrate in the leaves and its reduction in root increased nodular number though their development was inhibited under these conditions. These findings are in agreement with those reported by Singh (1958). Increase in the shoot/root ratio and C/N ratio of tops was affected by gibberellic acid again leading to the inhibition of the development of nodules, pointing out to the importance of controlled C/N ratio in nodulation.

#### Summary :

Influence of pre-soaking *Vigna catjang* (var. Russian mammoth) seeds in 10, 100, 200 and 400 ppm concentration of gibberellic acid in the form of potassium gibberellate on its subsequent growth, metabolism, resistance to drought and nodulation, was studied in partly controlled conditions of sand culture.

Linear growth of plant and stem elongation increased significantly by gibberellic acid application. The internode towards the base was more affected than the internodes towards the top. Total leaf area as well as that of individual leaf, chlorophyll content and root length decreased significantly. A decrease in photosynthetic efficiency, resistance to drought and a marked increase in transpiration rate was registered.

A significant decrease in fresh and dry weight of root, leaf and nodule was recorded. Significant increase in shoot/root ratio, stem weight, and decrease in root/nodule ratio on fresh as well as dry weight basis was recorded.

A significant increase in total carbohydrate content in gibberellic acid treated leaf and decrease in stem and root and a significant decrease in total nitrogen content in all the three parts was also noticed. The findings are discussed in the light of literature available.

#### References :

- A. O. A. C. 7th Ed. Washington, D. C., 1950.
- Anonymous. Gibberellic acid Tech. Bull. Merck and Co., 1957.
- Brian, P. W., Elson, G. W. Hemming, H. G. and Radley, M. The plant growth promoting properties of gibberellic acid, a metabolic product of the fungus, *Gibberella fujikuroi*. *Sci. Food Agri.*, **5** : 602-612, 1954.
- Brian, P. W. and Hemming, H. G. The effect of gibberellic acid on shoot growth of pea seedlings. *Physiol. Plantarum*, **8** : 669-681, 1955.
- Brian, P. W., Hemming, H. G. and Lowe, D. Inhibition of rooting of cuttings by gibberellic acid. *Ann. Bot.*, **24** : 407-419, 1960.
- Deats, M. E. The effect on plants of the increase and decrease of the period of illumination over that of the normal day period. *Am. J. Bot.*, **12** : 384-392, 1925.
- Eaton, S. V. Effects of variation in day length and clipping of plants on nodule development and growth of soybean. *Bot. Gaz.*, **91** : 113-144, 1931.
- Eagle, D. R. and Bird, L. S. Preliminary experiments employ in gibberellic acid as a cotton seed-treatment. *U. S. Dept. Agri. Plant Disease Rept.*, **42** : 320-323, 1958.
- Fisher, R. A. Statistical methods for research workers, Oliver and Boyd Ltd., Edinburgh, 1950.
- Fletcher, W. W., Alcorn, J. W. and Raymond, J. C. Gibberellic acid and nodulation of legumes. *Nature*, **184** : 1576, 1959.
- Gray, R. A. Alteration of leaf size and shape and other changes caused by gibberellins in plants. *Am. J. Bot.*, **44** : 674-682, 1957.
- Gopalachari, N. C. and Naidu, K. M. Response of wrapper tobacco to gibberellic acid and maleic hydrazide. *Indian J. Agron.*, **6** : 15-21, 1961.
- Hayashi, T. The biochemistry of Bakovac fungi. Part 6. Effect of gibberellin on the activity of amylase in germinated cereal grains. *J. Agri. Chem. Soc. Japan*, **16** : 531-538, 1940.
- Hewitt, E. J. A technique for large scale pot and sand culture. *A. R. Long Ashton Agric. Hort. Res. Sta.*, 1947.
- Iljin, W. S. Drought resistance in plants and physiological processes. *Ann. Rev. Plant Physiol.*, **8** : 257-274, 1957.
- Kessler, B. Nucleic acids as factors in drought resistance of higher plants. *Recent. Adv. Bot.*, **2** : 1153-1159, 1959.
- Kaloyereas, S. A. A new method of determining drought resistance. *Plant Physiol.*, **33** : 232-233, 1958.

- Loomis, W. E. and Shull, C. A. Methods in plant physiology McGraw-Hill Book Company, New York and London, 1937.
- Marth, P. C., Audia, W. V. and Mitchel, J. W. Effect of gibberellic acid on growth and development of plants of various genera and species. *Bot. Gaz.*, **18** : 106-111, 1956.
- Mosolov, I. V. On the question of physiological role of gibberellic acid on plants. *Doklady Akad. Nauk. S. S. S. R.* **136** : 23-25, 1961.
- Raheja, P. C. Recent physiological investigations on drought resistance in crop plants. *Indian J. Agri. Sci.*, **21** : 335-346, 1951.
- Radley, M. Gibberellin-like substances in plants. *Nature*, **191** : 684-685, 1961.
- Sachs, R. M., Bertz, C. F. and Long, A. Shoot histogenesis. The early effects of gibberellin upon stem elongation in two rosette plants. *Am. J. Bot.*, **46** : 376-384, 1959.
- Singh, A. Influence of increase in day-length on growth behaviour, root nodulation and flower initiation in *Cicer arietinum*. *Proc. Nat. Acad. Sci.*, **27** (B) : 231-241, 1958.
- Singh, A. Effect of gibberellic acid on growth and yield of wheat. *Ibid*, vol. 33, part IV, pp. 511-521, 1963.
- Sandhu, A. S. and Husain, A. Effect of seed-treatment with gibberellic acid on germination and growth of Bajra (*Pennisetum typhoides*). *Indian J. Agron.* **5** : 269-272, 1961.
- Sytynk, K. M. The effect of gibberellin and hetero-auxin on the metabolism of plants. *Ukrain Bot. Zhur.*, **17** : 15-22, 1961.
- Thruber, G. A., Douglas, J. R. and Galston, A. W. Inhibitory effect of gibberellins on nodulizatoin in dwarf beans (*Phaseolus vulgaris*). *Nature*, **181** : 1082-1083, 1958.
- Wittwer, S. H. and Bukovac, M. J. Gibberellins new chemicals for crop-production. *Quart. Bull. Mich. Agri. Expt. Sta.*, **39** : 469-494, 1957a.
- Gibberellins and higher plants VIII Seed-treatment for bean, peas and sweet corn. *Quart. Mich. Agri. Expt. Sta.*, **40** : 215-224, 1957b.
- Yabuta, T. and Hayashi, T. *J. Agri. Chem. Soc. Japan*, **15** : 403-413, 1939.

# ECOLOGY OF *ERIGERON LINIFOLIUS* WILLD. HABITAT STUDIES

By

P. S. RAMAKRISHNAN

Department of Botany, Panjab University, Chandigarh, India

[Received on 16th January, 1964]

## Introduction :

The present study was undertaken to investigate the edaphic limits of *Erigeron linifolius* Willd., a very common weed of the Punjab during the rainy season. Eighteen sites from widely scattered regions of Punjab were chosen in such a way as to cover the areas where the species is luxuriant in its growth as well as the expected marginality for the occurrence of *E. linifolius*.

## Methods :

The density of the species at each site was determined by the percentage tiller measure as outlined by Lodge (1962). At each site an area of one square metre was demarcated and the density of the species is expressed as a percentage of the total population. A mean value of ten observations for dry weight of the shoot and the seed output was taken as an index of the performance of the species at each site.

Soil samples for analysis were collected from each site, from the rooting region of the plant (10 cm. depth). Moisture content, expressed as a percentage of the dry weight of the soil and pH were determined with fresh soil samples. pH was determined by the glass electrode method. The soils were then oven dried at 35°C for 24 hours and passed through a 2-mm. sieve. Exchangeable calcium, magnesium and potassium were determined in a 1 N. ammonium acetate extract by the method outlined by Piper (1944). Nitrate nitrogen in the soil was estimated colorimetrically following the phenol-di-sulphonic acid method (Snell & Snell, 1949). Exchangeable phosphate was determined colorimetrically using 1 N. sodium hydroxide as the extracting agent (Piper, 1944). Organic matter was determined by Robinson's method (Wright, 1939).

## Results and Discussion :

Soil analysis data for various sites investigated are given in Table 1.

The species occurs in well drained sites and from the data presented in Table 1 it is clear that the moisture content in the soil ranges between 6.4 to 22.0 per cent. pH of the soil seems to be of little consequence in determining the density and performance of the plant. It mostly grows in alkaline soils with a pH range of 7.1 to 8.3, though occasionally it may be met with in slightly acidic soils as in site 1 and site 10. The lowest pH at which the species was found was 6.3. Judging from the standards of the soil nutrient status for agricultural crops (Hughes, 1949), the soils are well supplied with calcium, potassium and phosphorus and *E. linifolius* exhibits a wide range of tolerance for these factors in the soil. The soils are also well supplied with exchangeable magnesium and the nitrate nitrogen varies from 3.0 to 10.0 mg./100g. of soil.

TABLE 1  
*Soil analysis data for Erigeron linifolius from various sites*

Site No.	Moisture (%)	pH	Exchangeable bases (m.e. %)			Exchangeable PO <sub>4</sub> (mg./100g.)	Nitrate Nitrogen (mg./100g.)	Organic matter (%)
			Calcium	Magnesium	Potassium			
1	19.5	6.9	14.8	7.08	3.49	20.0	6.3	1.34
2	22.0	7.4	10.5	7.18	3.27	19.0	4.5	0.97
3	17.8	7.2	10.9	3.35	3.51	23.0	5.8	2.54
4	15.6	7.4	11.4	6.17	2.99	25.0	5.3	3.03
5	7.3	7.7	25.9	12.68	4.06	12.0	7.5	7.29
6	21.5	8.2	10.4	9.10	3.91	36.0	9.8	4.67
7	6.4	8.1	36.7	8.17	2.82	10.0	10.3	2.49
8	6.5	7.5	13.4	6.94	3.89	13.0	8.0	1.28
9	10.7	7.1	12.3	6.17	1.38	10.0	8.3	1.40
10	18.3	6.6	12.0	7.42	3.61	9.0	10.0	1.46
11	9.6	7.5	6.1	6.17	2.98	10.0	3.5	1.70
12	21.0	8.3	8.1	6.17	3.55	8.0	5.0	1.80
13	20.7	7.2	11.0	9.34	2.91	22.0	3.0	1.43
14	8.9	6.3	9.7	6.17	3.79	15.0	4.0	0.87
15	13.9	7.3	25.6	7.42	3.80	9.0	3.3	0.67
16	15.3	8.6	12.0	9.10	3.95	9.0	5.0	0.63
17	16.8	7.7	14.8	8.14	3.77	9.0	3.8	1.42
18	19.9	7.7	11.4	7.66	4.38	8.0	5.8	1.04

*E. linifolius* forms a conspicuous member of the ruderal communities of the Punjab plains and hills ascending to an altitude of 2133 m. and grows in soils rich in organic matter. While working on the distribution of this species on the Kasauli hill (1828 m. altitude approx.), which is one of the outermost ranges of the Himalayas, it was found that the plant is not uniformly distributed throughout the hilly tracts. It occurs only in disturbed sites with a good amount of decaying debris, confined especially to around the villages or where there is human habitation. In areas of natural forests, *E. linifolius* was absent. Hence, a detailed analysis of the soil was undertaken of the sites with and without *E. linifolius*. The mean analytical data with the standard error values are given in Table 2.

No significant difference at 5 per cent level could be observed in any of the factors except organic matter. The organic matter level of the soils in sites without *E. linifolius* is much lower than in the sites where the plant grows. However, from the preliminary observations that have been made, it also appears that this species may not be able to withstand the competitive rigours in a closed

forest, besides the differences observable in the organic matter content and its consequent effect upon the physical and chemical constitution of the soil.

TABLE 2  
*Mean values for various soil factors with and without Erigeron linifolius in Kasauli Hills*

	Moisture	pH	Exchangeable bases (m.e. %)			Exchangeable $\text{PO}_4$ (mg./100g.)	Nitrate Nitrogen (mg./100g.)	Organic matter (%)
			Ca	Mg	K			
E. linifolius	15.62	7.5	13.98	3.54	7.59	22.5	6.53	3.32
	±	±	±	±	±	±	±	±
	2.20	0.18	2.48	0.16	1.27	3.5	4.93	0.96
No E. linifolius	17.97	7.9	16.75	3.53	7.45	21.0	4.93	1.18
	±	±	±	±	±	±	±	±
	4.16	0.09	1.80	0.19	0.44	5.5	0.21	0.26
Probability	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.05

In order to find out as to whether there is a significant correlation between habitat factors and performance of the species total correlation coefficient values were worked out and the result is presented in Table 3.

TABLE 3  
*Total correlation coefficients between soil factors and plant growth*

	Density of the species	Dry weight of the shoot	Seed output
Moisture content (%)	+0.623**	+0.209 N.S.	+0.316 N.S.
Exchangeable calcium (m.e. %)	-0.307 N.S.	-0.170 N.S.	-0.073 N.S.
Exchangeable magnesium (m.e. %)	-0.133 N.S.	+0.431 N.S.	+0.228 N.S.
Exchangeable potassium (m.e. %)	-0.076 N.S.	-0.155 N.S.	+0.157 N.S.
Exchangeable phosphorus (mg./100g.)	+0.067 N.S.	+0.223 N.S.	+0.560*
Nitrate nitrogen (mg./100g.)	-0.062 N.S.	-0.021 N.S.	+0.428 N.S.
Organic matter (%)	-0.379 N.S.	+0.119 N.S.	+0.566*
Density of the species	—	+0.735 ***	+0.006 N.S.

\*\*\* P = 0.001

\*\* P = 0.01

\* P = 0.05

N.S. = Not significant

Partial correlation coefficient values were also worked out taking into account the significant and marginal total correlation coefficient values and the data are set in Table 4.

TABLE 4  
Partial correlation coefficient between soil factors and plant growth  
(eliminated variate within brackets)

	Density	Dry wt. of shoot	Seed output
Moisture (%)	+0.670** (organic matter)	-	-
Exchangeable magnesium (m.e.%)	-	+0.788** (Density)	-
Exchangeable phosphorus (mg./100g.)	-	-	+0.594* (Nitrogen and organic matter)
Nitrate nitrogen (mg./100g.)	-	-	+0.403 N.S. (Phosphorus and organic matter)
Organic matter (%)	-0.441 N.S. (Moisture)	-	+0.422 N.S. (Phosphorus and Nitrate)
Density (%)	-	+0.890*** (Magnesium)	-

\*\*\* P = 0.001

\*\* P = 0.01

\* P = 0.05

N.S. = Not significant

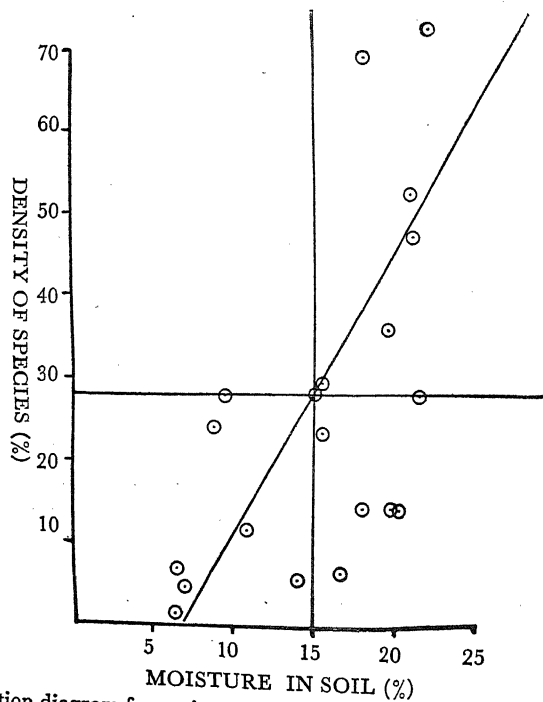


Fig. 1. Correlation diagram for moisture in soil and density of *E. linifolius* in different localities.

A positive correlation significant at 5 per cent level of probability was observed between moisture and density of the species within the range of 5.6-23.0 per cent of moisture in the soil (Fig. 1). Density of the species gave a positive correlation significant at 5 per cent level of probability, with the dry weight of the shoot (Fig. 2). Density of a species in any particular site being governed by the better nutrient and moisture supply in the habitat may explain for this significant correlation between the two variables. However, a partial correlation study between magnesium and dry weight of the shoot, eliminating density gives a significant value at 5 per cent level of probability (Fig. 3). This can be accounted as due to the elimination of the intraspecific competition which is likely to be operative in sites of higher density of this species. The seed output of *E. linifolius* shows a positive correlation with exchangeable phosphate in the soil (Fig. 4), but organic matter which was significantly correlated with seed output as seen from Table 3 becomes insignificant at 5 per cent level when the partial correlation value is worked out.

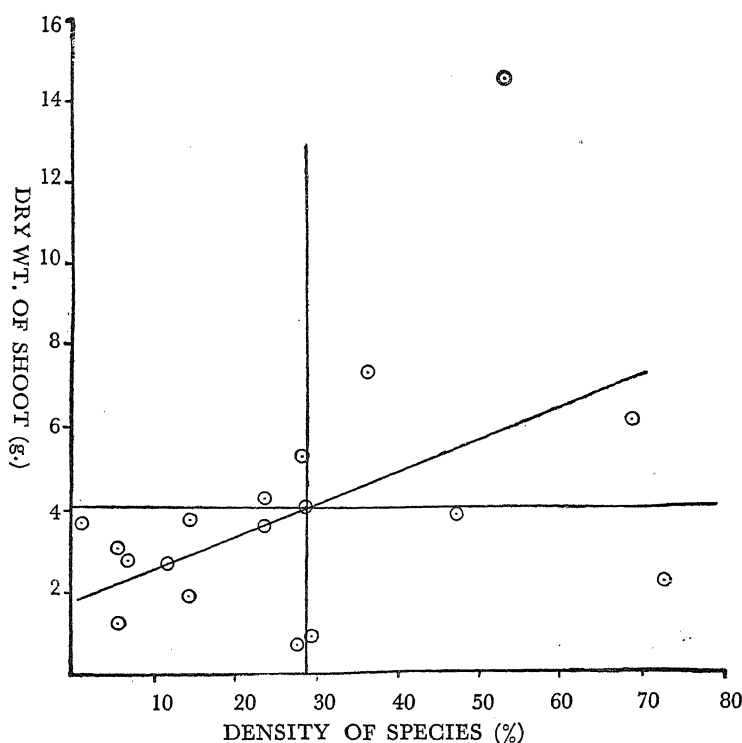


Fig. 2. Correlation diagram for density of *E. linifolius* and dry weight of the shoot of the species in different localities.

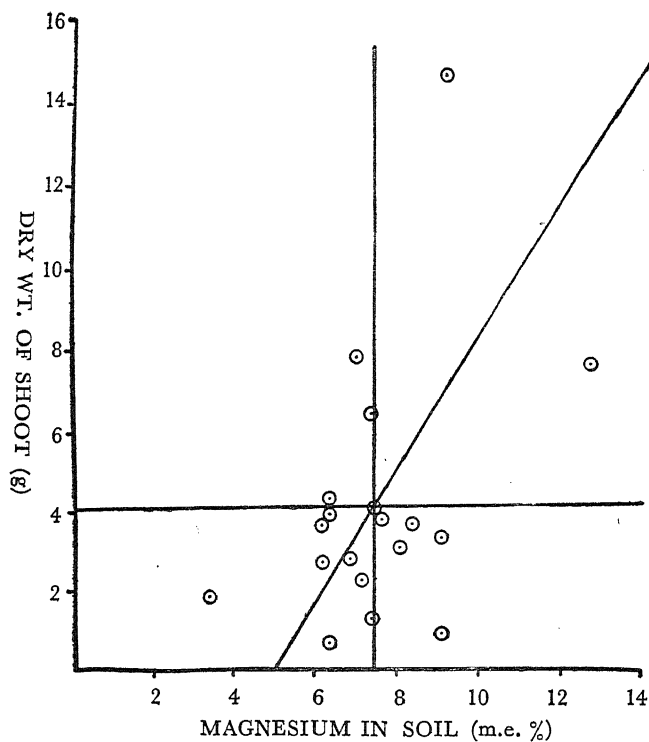


Fig. 3. Correlation diagram for exchangeable magnesium in the soil and dry weight of the shoot of *E. linifolius* in different localities.

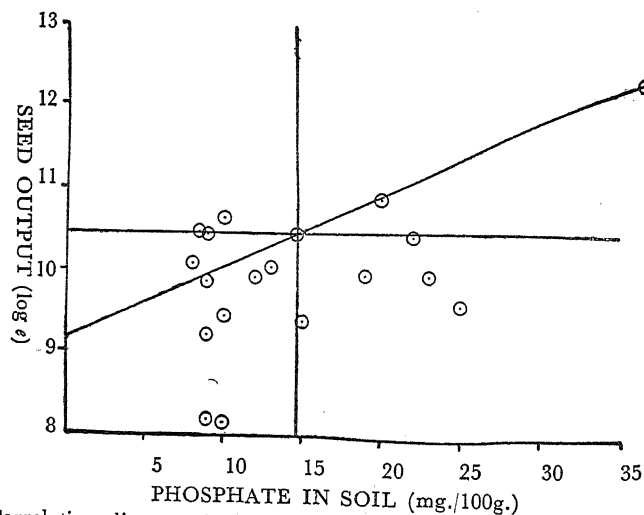


Fig. 4. Correlation diagram for exchangeable phosphate in the soil and seed output (log e) of *E. linifolius* in different localities.

The present study emphasises the large variation in the edaphic factors and the wide range of tolerance of *E. linifolius*. While some of the factors do not influence the performance of the plant to a great extent, others like moisture, exchangeable magnesium and phosphates show correlations with density, dry weight of the shoot and seed output of the species. Organic matter in the soil seems to have an important role in the restriction of the species to near about human habitations. This is, perhaps, due to the addition to the soil of a large amount of waste products thus increasing the organic matter level of the soil. Besides, the influence of competition in a closed forest cannot also be overlooked, while accounting for this peculiar pattern of distribution. In all the sites that have been studied it was remarkable to note that the species are always restricted to disturbed sites, around human habitations, devoid of natural forest vegetation.

Regarding its calcium requirement, *E. linifolius* may be considered as an indifferent species having a tolerance range for this factor from as low as 6.1 m.e. per cent to 36.7 m.e. per cent. Though no significant correlation could be established between this factor and the performance of the plant, in sites 7, 5, 15, 17 and 8 where there is a moderately high amount of calcium in the soil, the density of the species is very low being 1.2, 4.6, 5.6, 6.4 and 6.9 per cent respectively.

### Summary :

The present study was undertaken to investigate the edaphic factors influencing the distribution of *Erigeron linifolius* Willd. The species is not found to grow in permanently wet soil and the density of the plant increases with increase in moisture level of the soil, within its tolerance range. Evidence is adduced to show that the species grows only in disturbed sites, rich in organic matter, especially near about human habitations. Positive correlations significant at 5 per cent level of probability have been observed between exchangeable magnesium of the soil and dry weight of the shoot, density of the plant and dry weight of the shoot and phosphorus in the soil and seed output of the plant. It has been found that though the species has a wide tolerance range with respect to exchangeable calcium in the soil, there is a tendency for a decrease in the density of the species in calcareous soils.

### Acknowledgements :

I am grateful to Professor R. Misra, Head of the Department of Botany, Banaras Hindu University for valuable suggestions and critically going through the manuscript and to Professor P. N. Mehra, Head of the Botany Department, Panjab University, for encouragement and laboratory facilities.

### References :

- Lodge, R. W. Autecology of *Cynosurus cristatus* L. Part I. Habitat studies. *J. Ecol.*, **50** : 63-73, 1962.
- Piper, C. S. *Soil and plant Analysis*. Interscience Publishers Inc., New York, 1944.
- Snell, F. D. and Snell, C. T. *Colorimetric Methods of Analysis*. Vol. II. D. Van Nostrand Co., Inc., New York, 1949.
- Wright C. H. *Soil Analysis* A handbook of physical and chemical methods. Thomas Murby & Co., London, 1939.
- Hughes, R. E. The vegetation of the north-western Conway valley, North Wales. *J. Ecol.*, **37** : 306-334, 1949.

# EFFECT OF CERTAIN CHEMICALS ON THE VERNALIZATION OF INDIAN CROP PLANTS

By

S. C. CHAKRAVARTI

Government Degree College, Mhow (M.P.)

[Received on 19th February, 1964]

## Introduction :

Leopold and Guernsey (1953*a, b*, 1954) reported the promotive effects of a combined treatment of certain chemicals and short exposure to low temperature (chemical vernalization) on the flowering of several plants. They found *α*-naphthaleneacetic acid, parachlorophenoxyacetic acid, 2 : 3 : 5-tri-iodobenzoic acid and thiamine to be effective, while it was not so in the case of *p*-aminobenzoic acid, penicillin, bacitracin and nicotinic acid.

Since the publication of the work of Leopold and Guernsey, chemical vernalization has been tried by a number of workers with more or less contradictory results. Thus Chakravarti and Pillai (1955) found a promotive effect on *Brassica campestris* with indoleacetic acid, indolebutyric acid and naphthaleneacetic acid, which, however, inhibited the process of vernalization in *Linum* (Chakravarti, 1954). In *Sesamum indicum* (Chakravarti, 1956) none of the auxins tried could produce earliness in flowering when unsplit seeds were used for sowing. Kojima *et al* (1957) while working with "Minowase Daikon", a race of Japanese radish plant failed to find any strengthening of low temperature effect through the application of naphthaleneacetic acid. Napp-Zinn (1958) recorded that the effect of subsequent vernalization treatment was diminished in *Arabidopsis thaliana* by soaking seeds with certain concentration of  $\text{KH}_2\text{PO}_4$  solution. Krekule (1961) reported that the vernalization process in winter wheat could be completely arrested through the soaking of seeds before chilling with sodium azide solution. On the other hand, successful chemical vernalization of several strains of Japanese radish with naphthaleneacetic acid and gibberellic acid was achieved by Tsukamoto and Asahira (1958). Kagawa (1956) also obtained positive results with the former chemical in spinach. Séchet (1953) investigated the relation between vitamins and vernalization. Subsequent soaking of seeds of lupines in lactoflavin, ascorbic acid, aneurin, nicotinic acid and nicotinamide was found to enhance the previous vernalization effect.

Present investigation has been undertaken with a view to determine the possibility of chemical vernalization in several Indian crop plants, some of which respond positively to normal vernalization, while others not. Chemicals belonging to the following groups were used :

- (a) Growth regulators,
- (b) Amino acids,
- (c) Vitamins and coconut milk, and
- (d) Respiratory inhibitors.

Results obtained with sulfadruugs and antibiotics on *Brassica*, *Cicer*, *Lens* and *Linum*, with certain growth regulators on *Lens* and *Linum* and with gibberellic acid on *Brassica* have already been reported in previous communications (Chakravarti, 1954, 1958a, b and 1959).

### Material and Methods :

Experiments were undertaken with the seeds of the following crop plants :

- (i) Mustard : *Brassica campestris* L., T. 10 S. 13
- (ii) Gram : *Cicer arietinum* L., T. 87
- (iii) Linseed : *Linum usitatissimum* L., N. P. 9
- (iv) Wheat : *Triticum vulgare* Vill. C. 13
- (v) Sesame : *Sesamum indicum* DC., N. P. 6 and N. P. 29
- (vi) Soybean : *Glycine Max* Merr. Var. Suttons' Clemson and Monetta
- (vii) Green gram : *Phaseolus radiatus* L., N. P. 36

They were soaked in solutions of different chemicals (partial immersion) contained in Petrie dishes for 8 hours at 30°C and allowed to sprout. Only those doing so within a reasonable time were transferred to the refrigerator. Seeds of sesame, soybean and green gram were chilled for 15 days at 8 to 10°C while mustard for 5 days, linseed for 12 days and the rest for 21 days at 3 to 5°C.

Treated seeds were sown in flower pots containing well manured garden soil along with (i) seeds soaked in water and chilled for the corresponding periods, (ii) seeds soaked in different solutions but not chilled, (iii) seeds chilled and then treated with different solutions, and (iv) seeds soaked in water only, depending upon the experiment.

In view of the extensive nature of the work, in majority of the cases (special-ly with *Brassica*) only records of the node number bearing the first flower were kept. According to Lang (1952, 1961) this is more advantageous to the determination of the time taken for anthesis as leaf number tells us whether initiation has been affected specifically or not. As the node of the first flower in gram varied on account of branching, the experimental plants were allowed to have only the main shoot growing through frequent trimmings of the side ones.

A list of the chemicals used, along with their concentrations, is given in table I. All of them were tried on mustard both for pre- and post-chilling treat-ment, while the experiments with wheat, sesame, soybean and green gram were confined to growth regulators, vitamins and amino acids and with gram and linseed to growth regulators only and these were used before subjecting the seeds to low temperature. In linseed the growth regulators used in a previous study (Chakravarti, 1954) were excluded.

In majority of the cases, treatments failed to produce any significant effect on the initiation of flowering. To save space, data for only those giving a positive result have been presented in the text.

Method of analysis of variance has been used to determine the statistical validity of the experiments.

### Experimental Findings :

**Morphological :** Different degrees of leaf fusion were induced in mustard plants raised from seeds treated with  $\alpha$ -naphthol 10 ppm., phenylacetic acid 10 ppm., trichloroacetic acid 100, 10 and 1 ppm., maleic acid 1 ppm., hydroxy-lamine hydrochloride 1 ppm. and semicarbazide hydrochloride 10 ppm.

TABLE I  
*Chemicals used for treatment of seeds of Indian crop plants*

Chemical	Conc. in ppm.
Gibberellic acid	100, 10, 1, 0.01
Indoleacetic acid	"
Indolebutyric acid	"
Indolepropionic acid	"
$\alpha$ -naphthaleneacetic acid	"
Phenyl acetic acid	100, 10, 1
Trichloroacetic acid	"
Monochloroacetic acid	"
2 : 4-Dichlorophenoxyacetic acid	"
2 : 3 : 5-Tri-iodobenzoic acid	"
2 : 4 : 5-Dichloroanisol	"
Transcinnamic acid	100, 10, 1, 0.01
$\alpha$ -naphthol	"
Diphenyl thiourea	"
Thiourea	"
Nicotine sulphate	"
Maleic hydrazide (MH 40)	2,000, 400, 100
Coconut milk	$\frac{1}{2}$ dil.
Ascorbic acid	100, 10, 1
Thiamine hydrochloride	"
Pyridoxine hydrochloride	"
Nicotinic acid	"
Calcium pantothenate	"
Inositol	"
Cysteine hydrochloride	"
<i>l</i> -arginine hydrochloride	"
Glycine	"
Biotin	"
Phenylhydrazine	1,000, 100, 1
<i>p</i> -nitrophenol	100, 1
Maleic acid	"
Hydroxylamine hydrochloride	"
Semicarbazide hydrochloride	"
Acid malonic	"
Sodium fluoride	"
Iodoacetic acid	"

Extensive cup formation comparable to that obtained by treatments with 2 : 4-dichlorophenoxyacetic acid and 2 : 3 : 5-tri-iodobenzoic acid reported by Pillai and Chakravarti (1954) was recorded only in the case of trichloroacetic acid 10 and 1 ppm.

*Flowering : Wheat, sesame, green gram and soybean :* None of the growth regulators, amino acids and vitamins used for pre-chilling treatments could bring about a significant lowering of the number of nodes bearing the first flower in these plants. On the other hand an increase has been noted in sesame, both chilled and unchilled, treated with maleic hydrazide and nicotinic acid (table II).

TABLE II

*Effect of soaking seeds of Sesamum indicum with different concentrations of maleic hydrazide and nicotinic acid, followed and not followed by chilling, on the node number bearing the first flower by plants raised from them. Number of plants are given within brackets*

Date of sowing : July 12, 1958

Treatment			Chilled		Unchilled	
			Increase in node number over water soaking		Increase in node number over water soaking	
Maleic hydrazide	2000 ppm.		15.7 (10)	4.5	16.2 (10)	4.7
"	"	400 "	13.2 (10)	2.0	13.7 (12)	2.2
"	"	100 "	12.4 (12)	1.2	12.1 (12)	0.6
Nicotinic acid	100	"	13.9 (12)	2.7	14.4 (12)	2.9
"	"	10 "	11.8 (10)	0.6	11.6 (11)	0.1
"	"	1 "	10.9 (10)	-0.3	11.4 (11)	-0.1
Water soaked			11.2 (12)	—	11.5 (12)	—

L. S. D. at 5% level : 2.2

*Mustard :* In one of the normal winter sowings, complete vernalization (3 weeks' chilling) of this plant has been found to bring down the node number from  $16.8 \pm 1.2$  in the control to  $7.1 \pm 0.7$  in the treated. In plants raised from seeds chilled for 5 days, the average node number bearing the first flower is  $13.4 \pm 0.8$ .

None of the chemicals in combination with 5 days' exposure to low temperature, either applied before or after it, could significantly bring down the node number beyond what has been observed with corresponding water vernalization thereby showing that these treatments do not affect flower initiation in mustard.

In treatment with certain concentrations of indoleacetic acid, indolebutyric acid, naphthaleneacetic acid, 2 : 4-dichlorophenoxyacetic acid and 2 : 3 : 5-tri-iodobenzoic acid, a record of the time taken for anthesis was also kept for plants raised from seeds chilled for 5 days and 21 days. Data collected are presented in table III from which it would be seen that pre-chilling treatment with the first three growth regulators brings about significant earliness in anthesis in partially vernalized seeds only, which disappears when the seeds are fully vernalized. In the case of the other two, the inhibitory effect, however, persists throughout the entire period of chilling.

TABLE III

*Days taken for anthesis by mustard plants raised from seeds treated with certain growth regulators and then chilled for 5 days and 21 days; leading to partial and complete vernalization respectively. Number of plants are given within brackets*

Date of sowing : October 24, 1958

Chemicals	5 days chilling		21 days chilling	
	Days for anthesis	Earliness over water vernalized	Days for anthesis	Earliness over water vernalized
IAA 100 ppm.	42.2 (10)	4.6	30.1 (12)	1.2
IBA 100 ppm.	43.0 (9)	3.8	30.4 (10)	0.9
NAA 100 ppm.	41.0 (12)	5.8	31.8 (9)	-0.5
TIBA 100 ppm.	50.6 (10)	-3.8	37.9 (10)	-6.6
2 : 4-D 10 ppm.	51.4 (12)	-4.6	37.2 (12)	-5.9
Water vernalized	46.8 (10)	—	31.3 (10)	—
Control	52.3 (10)	-5.5	52.3 (10)	-21.0

L. S. D. at 5% level : 3.2

TABLE IV

*Days taken for anthesis and the number of leaves to the inflorescence in linseed plants raised from seeds treated with certain growth regulators and then chilled for 12 days. Number of plants are given within brackets*

Date of sowing : October, 30, 1957

Chemical	Conc. ppm.	Anthesis in days	Delay over water vernalized*	Leaf No.	Increase over water vernalized**
Indolepropionic acid	100	68.4 (7)	25.5	78.9	10.5
" "	10	66.5 (8)	23.6	77.5	9.1
" "	1	56.2 (8)	13.3	73.6	5.2
Monochloroacetic acid	1	70.3 (10)	27.4	78.4	10.0
$\alpha$ -Naphthol	10	64.6 (10)	21.7	80.6	12.2
" "	1	62.4 (10)	19.5	83.2	14.8
Phenylacetic acid	10	67.6 (9)	24.7	85.4	17.0
" "	1	61.0 (7)	18.1	80.2	11.8
2 : 4-Dichlorophenoxyacetic acid	1	66.4 (9)	23.5	79.2	10.8
2 : 3 : 5-Tri-iodobenzoic acid	10	62.3 (10)	19.4	83.2	14.8
" "	1	60.4 (9)	17.5	80.6	12.2
Diphenyl-thiourea	100	58.9 (9)	16.0	70.6	2.2
" "	10	55.4 (8)	12.5	70.2	1.8
" "	1	50.2 (10)	7.3	69.4	1.0
Nicotin sulphate	1000	53.4 (10)	10.5	80.1	11.7
" "	100	50.1 (10)	7.2	78.6	10.2
" "	1	46.5 (9)	3.6	66.4	-2.0
Water vernalized	—	42.9 (10)	—	68.4	—
Unvernalized control	—	74.8 (10)	31.9	140.2	71.8

\*L. S. D. at 5% level : 3.9

\*\*L. S. D. at 5% level : 2.5

**Linseed :** Of the different growth regulators used, pre-chilling treatment with certain concentrations of indolepropionic acid, monochloroacetic acid,  $\alpha$ -naphthol, phenylacetic acid, 2 : 4-dichlorophenoxyacetic acid 2 : 3 : 5-tri-iodobenzoic acid, diphenyl-thiourea and nicotin sulphate brought about different degrees of nullification of the chilling effect (table IV). Rest either interfered with the germination of the seeds or failed to induce any change in the floral induction.

**Gram :** Pre-chilling soaking of seeds with several growth regulators has brought about significant decrease in node numbers, the data for which are presented in table V. Maximum effect is seen in treatment with 100 ppm. indoleacetic acid, followed by that in 100 ppm. transcinamic acid and 1 ppm. trichloroacetic acid.

TABLE V

*Node number of flowering in gram plants raised from seeds treated with certain growth regulators and chilled for 21 days. Number of plants are given within brackets*

Date sowing : October 22, 1957

Chemical	Conc. ppm.	Node number	Decrease over water vernalized
Napthaleneacetic acid	100	16.3 (8)	1.9
"      "	25	16.8 (10)	1.4
"      "	1	16.6 (7)	1.6
Indoleacetic acid	100	13.9 (8)	4.3
"      "	25	14.8 (6)	3.4
"      "	1	16.7 (7)	1.5
Indolebutyric acid	100	16.5 (11)	1.7
"      "	25	17.8 (10)	0.4
"      "	1	17.8 (10)	0.4
$\alpha$ -Naphthol	100	16.0 (7)	2.2
Phenylacetic acid	100	17.0 (12)	1.2
Trichloroacetic acid	1	14.4 (9)	3.8
Transcinamic acid	100	14.3 (9)	3.9
Monochloroacetic acid	100	16.9 (11)	1.3
Water vernalized		18.2 (12)	—
Water control		20.9 (11)	2.7

L. S. D. at 5% level : 1.2

#### Discussion :

Crops studied could be divided into two groups, vernalizable and non-vernalizable, the first being represented by mustard, gram and linseed, while the second by wheat strain C. 13, sesame, green gram and soybean. The last three are grown during the rainy season and the rest during the winter. So far all attempts to vernalize rainy season crop plants and also certain strains of Indian wheat including the present one have proved to be a failure. With the discovery of the

phenomenon of chemical vernalization, expectations arose (Chakravarti and Pillai, 1955) that this process might bring about a shortening of the life-cycle of plants which fail to respond to normal vernalization. This, however, has not been fulfilled in the present study.

As regards winter crops, their response to a particular chemical varies. Flower initiation in mustard, vernalized maximally, as determined by node number and anthesis remains unaffected by any kind of pre-chilling treatment. Time taken for anthesis in partial vernalization (without any change in the node number) is affected and hormones like IAA, NAA and IBA act as synergists. A disagreement in the results obtained through node number and anthesis has also been recorded by workers in the field. Thus Rappaport *et al* (1956) found that in lettuce, soil temperature influences the rate of seed stalk development *i.e.* days to anthesis but not the leaf number preceding the inflorescence. Evans (1959) working with *Vicia faba* plants observed that once the vernalization response is saturated, further exposure to low temperature, only delays flower initiation although it reduces the node of first flowering.

In linseed, pre-chilling soaking with a number of growth regulators has brought about a considerable degree of nullification of the effect of low temperature which is in conformity with the previous findings of Chakravarti (1954) with IAA, IBA and NAA. It is rather interesting to note that certain sulfadruugs and antibiotics also act in a similar way on the vernalization of this plant (Chakravarti, 1959). *Lens* is another plant where also a similar relation between chilling and certain hormones (Chakravarti, 1958a), sulfadruugs and antibiotics (Chakravarti, 1959) exists.

Gram, however, presents a different picture with a high degree of acceleration of the chilling effect due to pre-treatment with certain growth regulators only.

Tsukamoto and Asahira (1958) in their investigation on chemical vernalization of several varieties of Japanese radish with different concentrations of NAA and GA suggested that nullification of the vernalization effect observed by Chakravarti (1954) should be considered under the climatic condition of India. Yamasaki (1947) while working with wheat embryo could not find any acceleration in the vernalization effect due to pre-chilling soaking with NAA. Vieitez (1953) working in Spain failed to find any earliness in Maize plants raised from seeds treated with IAA and then chilled for different periods. Even under similar climatic conditions of India, different plants responding to ordinary chilling fail to react similarly when treated with the same group of chemicals. In the opinion of the author, response to chemical vernalization is a gene controlled characteristic as is the case with normal vernalization.

Evans (1959) working with *Vicia faba* found that seeds soaked in none of the solutions of several amino acids at various concentrations followed by a low temperature treatment of 4°C for 7 days gave a significant lowering of the time of floret appearance. Present investigation with wheat, sesame, green gram and soybean confirms this.

Of the various groups of chemicals used, growth regulators are the only ones effective in inducing chemical vernalization, which is in conformity with the findings of other workers in the field (Leopold and Guernsey, 1953a, b, 1954; Chakravarti and Pillai, 1955; Kagawa, 1956; Rappaport *et al* 1956; Tsukamoto and Asahira, 1958; Misra and Sahu, 1960 and Mitra, 1961). Further experiments with

these only are suggested to evaluate the agricultural possibilities of the process in India.

### Summary and Conclusions :

Present investigation has been undertaken to determine the effect of pre- and post-chilling treatment of seeds of mustard with certain growth regulators, amino acids, vitamins and respiratory inhibitors ; pre-chilling treatment of seeds of gram and linseed with growth regulators and of wheat, sesame, green gram and soybean with these and amino acids and vitamins on the process of their flower induction.

In mustard, flowering as revealed by node number is not affected by the use of any of the chemicals, either before or after low temperature treatment. Pre-chilling soaking of seeds with IAA, IBA and NAA brings about an extra earliness in anthesis in plants raised from partially vernalized seeds only, which, however, disappears as the seeds are fully vernalized.

In gram, soaking of seeds with most of the growth regulators, before chilling, brings about a significant decrease in the node number bearing the first flower in plants raised from them in comparison to those raised from seeds soaked in water. In linseed similar treatments result in nullification of the low temperature effect.

Pre-chilling soaking treatment of seeds of non-vernalizable plants like wheat, sesame, green gram and soybean with growth regulators, vitamins and amino acids fails to induce earliness in flowering thereby showing that the deficiency in them, due to which they do not respond to chilling, can not be made up with any of the chemicals belonging to the groups mentioned above.

In view of encouraging results with gram, further experiment with growth regulators only are suggested to evaluate the agricultural possibilities of chemical vernalization in India.

### References :

- Chakravarti, S. C. Inhibition of vernalization in *Linum usitatissimum* Linn. by certain synthetic hormones, *Nature*, **174** : 461, 1954.
- Effects of certain synthetic growth regulators in the process of vernalization of *Sesamum indicum* L. *Agra Univ. Jour. Res. (Sci.)*, **5** : 343-345, 1956.
- Effect of certain synthetic auxins and their antagonists on the process of vernalization of *Lens esculenta* Moench. *Proc. 45th Ind. Sci. Cong.*, **3** : 306, 1958a.
- Gibberellic acid and vernalization. *Nature*, **182** : 1612, 1958b.
- Effect of sulfadruugs and antibiotics on the vernalization of certain Indian crop plants. *Proc. Nat. Acad. Sci. India*, Sec. B, **29** : 225-229, 1959.
- and Pillai, V. N. K. Studies in auxin-vernalization relationships I. The effect of certain synthetic auxins and their antagonists on the vernalization of *Brassica campestris* L. *Phyton*, **5** : 1-17, 1955.
- Evans, L. T. Environmental control of flowering in *Vicia faba* L. *Ann. Bot. N. S.*, **23** : 521-546, 1959.
- Kagawa, A. Studies on the floral induction of slow bolting varieties in spinach. I. Effect of chemical vernalization and low temperature treatment of seeds. *Jour. Hort. Assoc. Japan*, **25** : 173-180, 1956.

- Krekule, J. The length of the first leaf-blade of winter wheat is not an indicator of vernalization. *Biol. Plantarum (Praha)*, **3** : 85-88, 1961.
- Kojima, H., Yahiro, M. and Eto, T. On the influence of auxins and anti-auxins upon vernalization. *Jour. Fac. Agri. Kyūshū Univ.*, **11** : 25-35, 1957.
- Lang, A. Physiology of flowering. *Ann. Rev. Plant Physiol.*, **3** : 265-306, 1952.
- Auxins in flowering. *Encyclopedia of Plant Physiology*, **14** : 908-950, 1961.
- Leopold, A. C. and Guernsey, F. S. Interaction of auxin and temperatures in floral initiation. *Science*, **118** : 215-217, 1953a.
- Modification of floral initiation with auxins and temperatures. *Amer. J. Bot.*, **40** : 603-607, 1953b.
- Flower initiation in the Alaska pea. II. Chemical vernalization. *Amer. J. Bot.*, **41** : 181-185, 1954.
- Misra, G. and Sahu, G. Chemical vernalization in an early variety of rice. *Proc. 47th Ind. Sci. Cong.*, **3** : 388, 1960.
- Mitra, G. N. A study on the effect of IAA and TIBA on vernalized paddy. *Curr. Sci.*, **30** : 395, 1961.
- Napp-Zinn, K. Über den Einfluss von  $\text{KH}_2\text{PO}_4$  auf die Vernalization. *Z. Botanik*, **46** : 506-515, 1958.
- Pillai, V. N. K. and Chakravarti, S. C. Effect of certain synthetic growth regulators on the form of leaf of *Brassica campestris* Linn. and *Lens esculenta* Moench. *Agra Univ. Jour. Res. (Sci.)*, **3** : 317-322, 1954.
- Rappaport, L., Wittwer, S. H. and Tukey, H. B. Seed vernalization and flowering in Lettuce (*Lactuca sativa*). *Nature*, **178** : 51, 1956.
- Séchet, J. Contribution à l'étude de la printanisation. *Botaniste*, **37** : 1-289, 1953.
- Tsukamoto, Y. and Asahira, T. Studies on chemical vernalization of radish. *Mem. Res. Inst. Food. Sci., Kyoto Univ.*, No. **14** : 1-13, 1958.
- Vieitez, E. Estudios sobre la vernalizacion del Maiz. *An. De Edafol. Fisiol. Veg.*, **12** : 1-8, 1953.
- Yamasaki, Y. Supplemental studies on vernalization of common wheat by embryo transplantation. *Seibutu*, **2** : 181-184, 1947.

# STUDIES ON A VIRUS DISEASE OF RADISH (*RAPHANUS SATIVUS* L.)

By

R. D. JOSHI and K. S. BHARGAVA

Department of Botany, Gorakhpur University, Gorakhpur, India

[Received on 26th December, 1963]

Radish plants showing mosaic symptoms were noticed in different cultivated fields. Similar symptoms were noticed on *Brassica rapa* L., *Brassica juncea* var. *rugosa* and *Lepidium ruderale* L., a perennial weed. The diseased plants were very prevalent in Naini Tal, Ranikhet, Bhimtal and other parts of Kumaon. On *Lepidium ruderale* the disease was visible in all the seasons of the year. Aphids were seen harbouring these plants and acted as vectors during migration. This weed, therefore, was a potential source of infection in the cultivated crops. By artificial inoculation it has been seen that the disease causes adverse effects on the growth and yield of infected plants which include some oil producing plants. The disease was found to result from infection with cabbage black ringspot virus. In the present studies, an isolate originally from radish was used.

## Materials and Methods :

All the experiments in the present studies were carried out in an insect-proof glass house maintained at a minimum temperature of 68°F, which was fumigated regularly to keep it free from insects. Test plants used for different experiments were grown in 4-inch pots. These were raised in insect-proof glasshouse where all precautions were taken to keep them free from any infection. The culture of the virus was maintained in radish. Mechanical inoculations were made using standard techniques ; infected tissues were ground in sterilised mortar, and their juice was expressed by squeezing the pulp through muslin cloth. 400-mesh carborundum powder was dusted lightly on the leaves of the test plants before they were rubbed with the forefinger wet with inoculum. In studying the host-range, attempts were made to recover the virus from inoculated plants, whether these showed any symptoms or not. Back inoculations were made to *Nicotiana tabacum* var. White Burley. Usually the inoculum was taken from young leaves, in some cases from the old inoculated leaves also. Aphids used in the present study were maintained and handled by similar methods as described by Watson (1936, 1938).

## Symptoms under field conditions :

Various naturally infected plants showed prominent symptoms under field conditions as described below :

1. *Raphanus sativus* L. 'Radish'. Infected plants show a clear mosaic mottling of the leaves, in which the darker bands are seen associated with the veinlets. Younger leaves in diseased plants show clearing of veins. No distortion or stunting is observed in any part of the plant.

2. *Brassica rapa* L. 'Turnip'. In diseased plants young leaves show mild vein-clearing. The older leaves are characterized by mosaic mottling, in which dark patches are seen along the bigger veins. There is slight distortion of the leaves. The plants become weak and stunted.

3. *Brassica juncea* Czern & Coss. var. *rugosa*. 'Badshah Lai'. Diseased plants show vein-clearing and mosaic mottling of the leaves. The dark green patches are mostly seen associated with few major veins, but sometimes smaller veins also have dark green bands along them.

4. *Lepidium ruderalis* L. 'Ban-Halim'. This is a widely distributed weed seen infected all the year. Infected plants show mosaic mottling of the leaves. Plants are also weak and stunted.

TABLE I  
*Symptoms produced on different hosts*

Host	Symptoms
<i>Brassica campestris</i> L. var. <i>sarson</i> and <i>Raphanus sativus</i> L.	Symptoms appear as vein-clearing of the young leaves followed by mosaic mottling.
<i>Brassica juncea</i> Czern & Coss var. <i>ramosa</i> . 'LAHI'	Vein-clearing followed by mosaic mottling. Leaves become distorted. The plants are stunted. The size of fruits and seeds is much reduced.
<i>Brassica oleracea</i> L. var. <i>capitata</i> and <i>B. oleracea</i> L. var. <i>botrytis</i> .	Blackish necrotic ringspots appear on the inoculated leaves. No systemic infection.
<i>Hesperis matronalis</i> L.	Vein-clearing, followed by mosaic mottling. Leaves are distorted. Petals show colour 'break'.
<i>Iberis umbellata</i>	Symptoms appear as vein-clearing followed by chlorotic spots and then mosaic mottling. Flowers show colour 'break'.
<i>Matthiola incana</i> R.Br.	Systemic vein-clearing, followed by mosaic mottling. Leaves may tend to roll upwards. Plants become stunted. Flowers show a colour 'break'.
<i>Chenopodium album</i> L.	Necrotic ringspots appear on the inoculated leaves.
<i>Nicotiana glutinosa</i> L.	Symptomless carrier of the virus.
<i>N. tabacum</i> L. var. White Burley	Numerous necrotic local lesions appear on inoculated leaves. These may enlarge and fuse together. No systemic symptoms.
<i>Petunia hybrida</i> Vilm.	Symptomless carrier of the virus.
<i>Zinnia elegans</i> Jacq.	Mosaic mottling. Flowers show colour 'break'.

### Host-range and Symptoms :

A number of plants belonging to different families were inoculated with infected sap. Symptoms produced on infected plants are given in table 1.

No symptoms were visible on any of the following plants, nor could the virus be recovered from them :

*Callistephus chinensis* Nees., *Cucurbita maxima* Duche., *Cucumis sativus* L., *Cyclanthura pedata* Schrad., *Lagenaria vulgaris* Ser., *Dolichos lablab* L., *Pisum sativum* L., *Phaseolus vulgaris* L., *Vicia faba* L., *Vigna sinensis* Savi., *Datura stramonium* L., and *Nicandra physaloides* Gaertn.

### Relation of temperature to expression of Symptoms :

Lebeau and Walker (1945) showed that different isolates of turnip mosaic virus induced severe symptoms at higher (28°C) than at lower temperature (16°C). Pound and Walker (1945) classified crucifer viruses on the basis of temperature reaction into two groups : turnip virus 1 group which showed acute symptoms at 28°C and mild at 16°C, and cauliflower virus 1 group where intensity of symptoms increased with decrease in temperature, and masking occurred at 28°C.

In the present study the symptoms exhibited by radish plants were quite brilliant and severe during summer (28°C). The symptoms became diffused during low temperatures in winter (below 13°C). Under natural conditions also the symptoms varied similarly.

### Insect Transmission :

Comparative tests with different aphids showed that *Aphis gossypii* Glov. and *Myzus persicae* Sulz. are the most efficient vectors of this virus. To determine the aphid-virus relationship the transmission tests with *Aphis gossypii* were made from infected radish plants to *Brassica juncea* var. *ramosa*. The following results were obtained :

#### 1. Effect of preliminary fasting and infection-feeding periods on the transmission.

Aphids were starved respectively for 0 hour, 1 hour and 4 hours before feeding on a diseased leaf for periods of 2 minutes, 15 minutes and 4 hours. Ten similarly treated aphids were transferred to each test plant, and were allowed to remain there for 24 hours. The results obtained are recorded in table 2.

TABLE 2

*Infection by A. gossypii with varying preliminary fasting and infection-feeding times on an average of ten plants*

Preliminary fasting time	Infection feeding-period			Total
	2 mts.	15 mts.	4 hrs.	
0 hr.	3	4	4	11
1 hr.	8	7	1	16
4 hrs.	9	7	1	17
Total	20	18	6	

From the above table it appears that preliminary fasting increases the number of infections only if the infection-feeding is short, and four hours preliminary starving has no greater effect than one hour. In the absence of preliminary starving, there is a slight increase in the number of infections with increasing infection-feeding.

2. *Minimum feeding period required on healthy plants to produce infection.*

To ascertain this, an experiment with the following treatments was made :

Preliminary fasting time	... 4 hrs.
Infection-feeding time	... 2 mts.
Feeding time on healthy plants	... 1, 2, 5, 15, and 30 mts.
Number of aphids per plant	... 5

The infection was obtained by a feeding time of even one minute on healthy plant, and with the increase in feeding time the number of infections obtained did not differ much. This shows that no incubation period is necessary but the aphids are capable of transmitting the virus to healthy plants immediately after leaving the infected plant.

3. *Effect of transferring aphids to a series of healthy plants after infection-feeding.*

Twelve aphids were given an infection-feeding after preliminary starvation. The following treatments were given :

Preliminary fasting time	... 4 hrs.
Infection-feeding time	... 2 mts.
Number of aphids per plant	... 1
Feeding time on each of the first four healthy plants	... 5 mts.
Feeding time on the fifth healthy plant	... 24 hrs.

TABLE 3  
*Number of successive plants infected by each aphid*

Number of plants	Number of aphid											
	1	2	3	4	5	6	7	8	9	10	11	12
1	+	-	+	-	-	+	-	+	-	+	-	+
2	+	-	-	-	-	+	-	-	-	-	+	-
3	-	-	+	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-

(+) sign indicates infection, and (—) shows no infection.

The results (table 3) show that of the 12 aphids used, 6 caused infection to the first plant, one to the second plant, 2 succeeded in infecting two successive plants and only one could infect the first and third successive plants. It appears

that the aphids cease to be infective very soon when feeding on test plants, but they can, nevertheless, cause more than one infection in this time.

#### 4. *Effect of fasting after infection-feeding.*

The aphids were given the following treatments :

Preliminary fasting time	... 4 hrs.
Infection-feeding time	... 2 mts.
Post-infection starving time	... 0, 5, 15, 30 mts. 1, 2, 6, 24 hrs.
Feeding time on healthy plants	... 24 hrs.
Number of aphids per plant	... 5

It was observed that the infectivity of the vectors was lost after two hours starvation and the capacity to produce infection decreases with the increase in starvation time.

The results obtained in these experiments show that the present virus falls within the non-persistent group of viruses as defined by Watson and Roberts (1939) and Watson (1946).

#### **Properties 'in vitro' :**

Sap from systemically infected leaves of radish was used as the source of virus for the following tests. Carborundum powder was used as an abrasive, before inoculation of *Nicotiana tabacum* var. White Burley assay plants. The results were :

<i>Thermal inactivation point</i>	... Between 58°C and 60°C for 10 mts.
<i>Resistance to ageing</i>	... Between 10 and 11 days at 20°-22°C.
<i>Dilution end-point</i>	... Between 1/10,000 and 1/100,000.

It has been reported that abrasives increase the efficiency of infection (Kalmus and Kassanis, 1945 ; Yardwood, 1957). An experiment was made to see the effect of carborundum powder on the dilution end-point of the virus. The results in table 4 show that carborundum increases the dilution end-point by 100 times. In addition, it also increases the number of local lesions produced.

TABLE 4  
*Average local lesions on tobacco var. White Burley (per half leaf)*

Dilution	Abrasive	No abrasive
Undiluted	111.0	5.4
1 : 10	100.6	4.0
1 : 100	25.0	1.0
1 : 1000	3.3	0.0
1 : 10,000	0.1	0.0
1 : 100,000	0.0	0.0

It is obvious that abrasive can not increase the virus content of an inoculum, so it must act by reducing the resistance of the host. It appears probable that it does so merely by increasing the number of cell injuries by rubbing, and so increases the likelihood of virus particles finding more entry points.

### Discussion :

Tompkins (1939) described a mosaic disease of radish that was not aphid-transmitted. Later on, however, Severin and Tompkins (1950) reported that the virus was easily transmitted by aphids. With the ever-increasing number of aphid-transmitted viruses attacking crucifers Walker *et al.* (1945) put all viruses with following characters in turnip virus 1 group : (a) which caused coarse mottling symptoms, in which symptom expression was prominent at temperatures above 24°C, (b) whose host-range was not limited to Cruciferae. Raychaudhuri and Pathanian (1955) made a detailed study of a disease causing mosaic in radish, but the virus had host-range limited to Cruciferae. Sylvester's (1953) proposal for creating a separate group for radish mosaic virus has not been accepted by the later workers (Horton *et al.*, 1961). A detailed study of different aspects of the present virus shows that it belongs to turnip virus 1 group and is similar to cabbage black ringspot virus (Smith, 1957) in methods of transmission, host-range and properties 'in vitro'.

A number of crucifer plants, viz. *Lepidium ruderale*, self sown plants of radish, turnip and *Brassica juncea* var. *rugosa* and their seed plants are found infected throughout the year. These can act as possible source of infection if the new crop is sown near them. Removal and destruction of such infected plants from the vicinity of these plots will control the spread of the disease to a large extent.

### Summary :

A mosaic disease of radish caused by cabbage black ringspot virus belonging to turnip virus 1 group has been studied. The other naturally infected plants include turnip, *Brassica juncea* and *Lepidium ruderale*. The vector virus relationship is of non-persistent type. *Lepidium ruderale* and seed plants of cultivated crucifers harbour the virus during unfavourable period. Destruction of such plants will control the spread of the disease to a great extent.

### Acknowledgement :

The authors are grateful to the Scientific Research Committee, Uttar Pradesh, for financial assistance during the course of investigations.

### References :

- Horton, I. C., Pound, G. S. and Pirone, T. P. Radish mosaic viruses. *Phytopathology*, **51** : 434, 1961.
- Kalmus, H. and Kassanis, B. The use of abrasive in the transmission of plant viruses. *Ann. appl. Biol.*, **32** : 320, 1945.
- Pound, G. S. and Walker, J. C. Differentiation of certain crucifer viruses by the use of temperature and host-immunity reactions. *J. agric. Res.*, **71** : 255, 1945.
- Raychaudhuri, S. P. and Pathanian, P. S. A mosaic disease of radish (*Raphanus sativus* L.). *Indian Phytopathology*, **8** : 99, 1955.
- Smith, K. M. *A Text book of Plant Virus Diseases*, 2nd Ed. (J. & A. Churchill Ltd., London, 652 pp., 1957.
- Sylvester, E. S. Host-range and properties of *Brassica nigra* virus. *Phytopathology*, **43** : 541, 1953.
- Tompkins, C. M. A mosaic disease of radish in California. *J. agric. Res.*, **58** : 119, 1939.

- Walker, J. C., Lebeau, F. J. and Pound, G. S. Viruses associated with cabbage mosaic. *J. agric. Res.*, **70** : 379, 1945.
- Watson, M. A. Factors affecting the amount of infection obtained by aphid transmission of the virus Hy. III. *Phil. Trans. Roy. Soc., B.* **226** : 457, 1936.
- Watson, M. A. Further studies on the relationship between *Hyoscyamus* virus 3 and the aphid *Myzus persicae* (Sulz.) with special reference to the effect of fasting. *Proc. Roy. Soc. B.*, **125** : 144, 1938.
- Watson, M. A. The transmission of beet mosaic and beet yellows viruses by aphides ; a comparative study of a non-persistent and persistent virus having host plants and vectors in common. *Proc. Roy. Soc. B.*, **133** : 200, 1946.
- Watson, M. A. and Roberts, F. M. A comparative study of the transmission of *Hyoscyamus* virus 3, Potato virus Y and Cucumber virus 1 by the vectors *Myzus persicae* (Sulz.), *M. circumflexus* (Buckton), and *Macrosiphum gei* (Koch.). *Proc. Roy. Soc. B.*, **127** : 543, 1939.
- Yardwood, E. C. Mechanical transmission of Plant Viruses. *Advances in Virus Research*, **4** : 243, 1957.

# ON SOME NOSTOCACEAE OF KANPUR DISTRICT

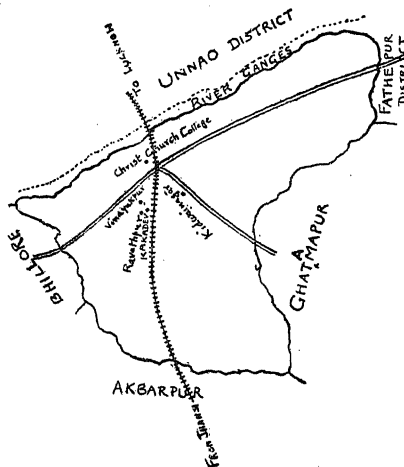
By

G. U. NAIR

Botany Department, Christ Church College, Kanpur

[Received on 2nd February, 1963]

Kanpur District situated in the upper Gangetic plain lies at 25°26' and 26°58' north latitude and 79°31' and 80°34' east longitude. The total area of the district is approximately 2361.66 square miles. It has a characteristic sub-tropical climate with an annual average rainfall of 82.47 cms. The region is rich in its algal flora and blue-green algae are quite conspicuous.



The algal flora of the district has not been recorded so far. The present communication, therefore, deals with some of the Nostocaceae collected during the year 1961-62. The places from where collections have been made are shown in the map. In all twelve forms have been described.

The list of algae collected is given in Table I. The forms are mostly found between pH 7.5-9.5.

TABLE I

Name of alga	Temp. of water	pH
1 <i>Cylindrospermum majus</i>	28°C	8
2 <i>Cylindrospermum michailovskoense</i>	21.5°C	8.5
3 <i>Nostoc linckia</i>	22°C	8
4 <i>Nostoc carneum</i>		
5 <i>Anabaena sphaerica</i> <i>A. sphaerica</i> var. <i>attenuata</i>	30.5°C	8.5
6 <i>A. ambigua</i>	20.5°C	7.5
7 <i>A. fullebornii</i>	31°C	8.5
8 <i>A. volzii</i>	28°C	9.5
9 <i>A. variabilis</i> var. <i>ellipsospora</i>		
10 <i>A. vaginicola</i> f. <i>fertilissima</i>		
11 <i>Nodularia spumigena</i>		
12 <i>Aulosira fritschii</i>	28°C	7.5

Systematic enumeration of the species observed

CYANOPHYCEAE

NOSTOCALES

Nostocaceae

Genus *Cylindrospermum* Kütz.

(1) *Cylindrospermum majus* Kützing ex Born. et Flah. Geitler, in Rabenhorsts Kryptogamenflora von Europa, Band XIV, Cyanophyceae, 1932, p. 815, fig. 520b; Desikachary, Cyanophyta, 1959, p. 362, pl. 80, Fig. 1.

Lat. trich.,  $3.12-4.63\mu$ ; long. cell.,  $3.12-7.41\mu$ ; lat. het.,  $4.68-5.85\mu$ ; long. het.,  $7.80-10.92\mu$ ; lat. spor.,  $8.58-11.70\mu$ ; long. spor.,  $17.55-26.52\mu$ .

The shape of the heterocysts varies from narrow cylindrical to oblong. The form differs from the type in having smaller spores.

Habitat.—In rice fields Kakadev, 30th September, 1961.

(2) *Cylindrospermum michailovskoense* Elenkin. Desikachary, *op. cit.*, 1959, p. 368, pl. 65, Fig. 1.

The description of the above species does not tally with the figures given by Kossinskaja (Kossinskaja, *Bull. Jardin Bot. princ. d. l'URSS*, 29, 119, pl. 1, fig. 3, 1930). It is suggested that the following description may be substituted for that given in Cyanophyta by Desikachary.

Thallus blue-green forming a thin and soft stratum; trichome pale blue-green, aggregated,  $3.12-3.90\mu$  broad; cells quadrate or cylindrical, constricted at the cross-walls,  $3.51-7.02\mu$  long; heterocysts oblong,  $4.29-5.07\mu$  broad,  $7.02-10.14\mu$  long; spores in series of 2-4, adjacent to the terminal heterocysts, sometimes separated by one or more vegetative cells, rarely single, ellipsoidal,  $6.24-10.14\mu$  broad,  $12.09-15.60$  ( $-21.84$ )  $\mu$  long; epispore smooth, colourless.

The form differs from the type in having narrower trichomes and smaller spores. (Fig. 1, a-d).

Habitat.—In standing rain water in a pool attached to aquatic plants, Ravatpur, 17th November, 1961.

Genus *Nostoc* Vaucher.

(3) *Nostoc linkia* (Roth) Bornet ex Born. et Flah. Geitler, *op. cit.*, 1932, p. 838, fig. 528b; Desikachary, *op. cit.*, 1959, p. 377.

Thallus irregularly expanding, shining blue-green; lat. trich.,  $3.12-3.90\mu$ ; long. cell.,  $3.51-4.68\mu$ ; lat. het.,  $4.68-5.46\mu$ ; long. het.,  $4.68-6.24\mu$ ; lat. spor.,  $4.29-6.24\mu$ ; long. spor.,  $4.68-7.80\mu$ .

Habitat.—Attached to grasses in a rain water pool, Vinayakpur, 17th November, 1961.

(4) *Nostoc carneum* Ag. ex Born. et Flah. Geitler, *op. cit.*, 1932, p. 839, fig. 530; Desikachary, *op. cit.*, 1959, p. 381, pl. 69, Fig. 6.

Thallus slimy globose first, later irregularly expanding, floating, dark brown; lat. trich.,  $3.90-4.29\mu$ ; long. cell.,  $4.68-7.80\mu$ ; lat. het.,  $6.24-8.58\mu$ ; long. het.,  $7.41-10.92\mu$ ; lat. spor.,  $5.46-8.58\mu$ ; long. spor.,  $6.24-11.31\mu$ .

# PLATE I

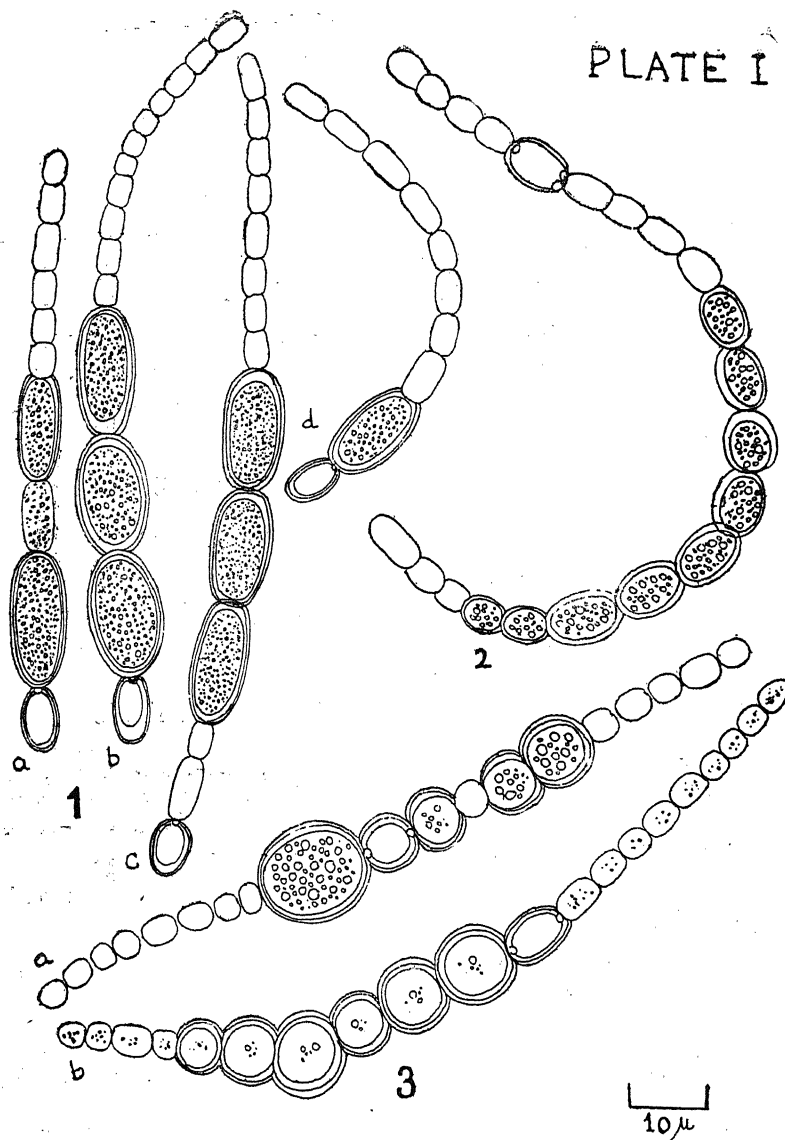


Fig. 1. *Cylindrospermum michailovskoense* Elenkin. a-d.  
 Fig. 2. *Nostoc carneum*. Ag.  
 Fig. 3. *Anabaena sphaerica* Bornet et Flahanet. a, b.

The spores in the present form are slightly larger than in the type species. (Fig. 2.)

Habitat.—Attached to aquatic plants or floating in a rain water pool, Ravatpur, 17th September, 1961.

#### Genus *Anabaena* Bory

(5) *Anabaena sphaerica* Bornet et Flahault. Geitler, *op. cit.*, 1932, p. 878; Biswas. *Records of the Botanical Survey of India*, Vol. XV—Part I, 1949, p. 58, Plate I, fig. 11; Desikachary, *op. cit.*, 1959, p. 393.

Lat. trich., 3.12–4.29 (–4.68) $\mu$ ; long. cell., 2.73–5.07 (–5.46) $\mu$ ; lat. het., 5.85–6.63 (–7.02) $\mu$ ; long. het., 6.6–8.19 $\mu$ ; lat. spor., (7.02–) 7.80–12.48 $\mu$ ; long. spor. (6.24–) 7.80–14.04 $\mu$ .

Habitat.—Free floating floccose masses in rice fields, Kidwainagar, 6th August, 1961.

*Anabaena sphaerica* Bornet et Flahault. var. *attenuata* Bharadwaja. *Proc. Ind. Acad. Sci.*, 1935, B, 2 : 103, fig. 5G–H.

Lat. trich., 2.34–4.68 (–6.24) $\mu$ ; long. cell., 2.34–4.68 $\mu$ ; lat. het., 5.85–7.02 $\mu$ ; long. het., 5.46–7.80 $\mu$ ; lat. spor., 10.92–14.04 $\mu$ ; long. spor., 14.32–17.16 (–20.28) $\mu$ . Spores may germinate while still attached to heterocyst.

The present form differs from the variety in having larger spores. Fritsch, (*Jour. Ind. Bot. Soc.*, 1949, 28, 153) however considers that the variety *tenuis* and var. *attenuata* do not differ appreciably from the type species.

Habitat.—Floating in a puddle, Kidwainagar, 31st August, 1961.

(6) *Anabaena ambigua* Rao, C. B. A new species of *Anabaena* (*Anabaena ambigua* sp. nov.), *Proc. Ind. Acad. Sci.*, 1937, B, 5 : 101–108, figs. 1, 2.

Lat. trich., 4.29–5.85 $\mu$ ; long. cell., (1.56–) 3.12–4.29 $\mu$ ; lat. het., 7.02–8.19 $\mu$ ; long. het., 6.24–7.41 $\mu$ ; lat. spor., 8.58–11.70 (–13.26) $\mu$ ; long. spor., 11.70–18.72 (–20.28) $\mu$ .

The form possesses slightly larger spores.

Habitat.—In standing water of a field, Vinayakpur, 4th November, 1961.

(7) *Anabaena fullebornii* Schindler. Geitler, *op. cit.*, 1932, p. 904, fig. 567e; Desikachary, *op. cit.*, 1959, p. 401, pl. 71, fig. 11 and pl. 75, figs. 1, 3.

Lat. trich., (3.90–) 4.29–4.68 $\mu$ ; long. cell., 4.68–8.97 $\mu$ ; lat. het., 5.85–7.02 $\mu$ ; long. het., 9.36–13.26 (–15.60) $\mu$ ; lat. spor., 10.14–15.21 $\mu$ ; long. spor., 22.62–36.66 $\mu$ .

Habitat.—Along with *Spirogyra species*, in a pond near river Ganges, 15th September, 1961.

(8) *Anabaena volzii* Lemm. Geitler, *op. cit.*, 1932, p. 901; Gupta. The Algal flora of some paddy fields and its importance in soil economy. *Jour. of Research*, 1957, Vol. 4, No. 1; Desikachary, *op. cit.*, 1959, p. 403, pl. 77, Fig. 1.

Lat. trich., (2.34–) 3.12–5.46 $\mu$ , long. cell., (4.68–) 6.24–12.48 $\mu$ ; lat. het., 5.46–7.80 $\mu$ ; long. het., 10.14–15.60 $\mu$ ; Spores ellipsoidal or spindle shaped, lat. spor., (5.46–) 7.02–17.16 $\mu$ ; long. spor., 20.28–32.76 (–70.20) $\mu$ .

The present form has narrower spores.

Habitat.—Along with *Tolypothrix species*, in a pond near river Ganges, 8th October, 1961.

(9) *Anabaena variabilis* Klitz. var *ellipsospora* Fritch. The Genus *Anabaena* etc., *Jour. Ind. Bot. Soc.*, 1949, 28, 142, figs. 40–50.

Lat. trich.,  $3.12-5.07\mu$  ; long. cell.,  $1.95-4.29\mu$  ; lat. het.,  $6.24-7.80\mu$  ; long. het.,  $6.24-8.58\mu$  ; lat. spor.,  $6.24-7.80\mu$  ; long. spor.,  $7.80-12.48 (-14.04)\mu$ .

Habitat.—On moist ground along with *Nodularia spumigena*, near river Ganges, 21st January, 1962.

(10) *Anabaena vaginicola* f. *fertilissima* Prasad. Some Nostocaceae from Uttar Pradesh, *J. Indian Bot. Soc.*, 31 : 361, figs. 14–17, 1952.

Lat. trich.,  $4.29-4.68$  ; long. cell.,  $3.90-4.68\mu$  ; lat. het.,  $5.07-7.41\mu$ , long. het.,  $5.07-7.41\mu$  ; lat. spor.,  $5.46-6.63\mu$  ; long. spor.,  $6.24-10.92\mu$ . Spores usually placed obliquely or transversely in the filament.

The present form differ from the type in having smaller spores.

Habitat.—In a pond at Magarwara near Kanpur, 26th August, 1962.

#### Genus *Nodularia* Mertens.

(11) *Nodularia spumigena* Mertens ex Born. et Flah. Geitler, *op. cit.*, 1932, p. 866, fig. 554b, c ; Bharadwaja. The Myxophyceae of the United Provinces, India-I *Proc. Ind. Acad. Sci.*, 1935, B, 2 (1) : 102 ; Desikachary, *op. cit.*, 1959, p. 423, pl. 80, Figs. 13, 14.

Lat. fil.,  $8.58-12.48\mu$  ; lat. trich.,  $7.80-10.92\mu$  ; long. cell.,  $3.12-5.46 (-6.24)\mu$ , lat. het.,  $9.36-14.04\mu$  ; long. het.,  $4.68-7.80\mu$  ; lat. spor.,  $10.14-14.04\mu$  ; long. spor.,  $6.24-10.92\mu$ .

The form differs from the type in having larger spores.

Habitat.—On moist ground, near river Ganges, 21st January, 1962.

#### Genus *Aulosira* Kirchner.

(12) *Aulosira fritschii* Bharadwaja. Desikachary, *op. cit.*, 1959, p. 432, pl. 80, Fig. 7–12.

Lat. fil.,  $11.70-15.99\mu$  ; crass. vag.,  $1.17-1.56$  ; lat. trich.,  $9.36-12.48\mu$  ; long. cell.,  $4.68-20.28\mu$  ; lat. het.,  $10.92-13.65\mu$  ; long. het.,  $11.70-28.08 (-37.44)\mu$  ; lat. spor.,  $11.70-13.26\mu$  ; long. spor.,  $9.36-28.08 (-35.88)\mu$ .

Habitat.—Floating in stagnant ponds, Vinayakpur, 12th October, 1961.

#### Acknowledgement :

I take this opportunity to express my thanks to Mr. Ninan Abraham, Principal, Christ Church College, Kanpur for providing me the necessary facilities for work and to Dr. A. B. Gupta, my respected teacher, for his valuable guidance and criticism.

# THE EFFECT OF GIBBERELLIC ACID ON THE GROWTH AND YIELD OF *LENS ESCULENTA*. MOENCH.

By

AMAR SINGH

*Department of Botany, University of Allahabad, India*

[Received on 23rd November, 1963]

Gibberellic acid is known to influence germination, growth, metabolism and yield of crop plants (Brian *et al.*, 1954 ; Gray, 1957 ; Sandhu and Husain, 1961 ; and Singh, 1963). Besides markedly modifying plant growth and development, gibberellins induce changes in the quantity of solid matter in various tissues (Brian and Elson, 1954 ; Meritt, 1958 ; Morgan and Mees, 1958). A few have worked on grain crop plants in order to evaluate the influence of gibberellin on their produce (Brian and Grove, 1957 ; Lona and Bocchi, 1956 ; and Singh, 1963).

In the present investigations the effect of gibberellic acid (GA) on the growth and yield of *Lens esculenta* has been studied.

## Material and Methods :

Micro-drop method of application of alcoholic solution of gibberellic acid (Singh, 1963) was followed. The concentrations used were 10, 100 and 1,000 ppm the total quantity of GA applied being 0.2, 2 and 20 mg. respectively. Two applications were made at weekly intervals starting from the time when the plants were one month old. Data for various growth and yield attributes were analysed statistically to assess the effect of gibberellic acid.

## Results :

The effect of gibberellic acid on the elongation of internodes for the second, third and fourth internodes were significant. Its effect (with exception of GA II concentration) on linear growth was significantly positive.

TABLE I

*Effect of gibberellic acid on average length of internodes of treated shoot of  
Lens esculenta. Moench.*

(Three weeks after treatment)

Treatments	Average linear growth of Internodes (cm)			
	1st	2nd	3rd	4th
Control	0.60	1.30	1.66	1.94
Alcohol	0.80	1.18	1.70	2.74
GA I	1.40	2.90	4.26	4.21
GA II	1.92	2.66	3.51	3.64
GA III	1.75	3.14	4.14	4.80
S.E.	0.14	0.56	1.11	0.53
C.D. at 1%	0.40	1.55	3.07	1.48
C.D. at 5%	0.30	1.15	2.28	1.09

GA I = 10 ppm ; GA II = 100 ppm ; GA III = 1,000 ppm

In the case of the first internode from base, however, the GA II treatment proved better than GA III (Table 1). The topmost internode exhibited significantly greater length under the influence of GA III level alone. In other cases (GA I and GA II) the third internode showed slight elongation.

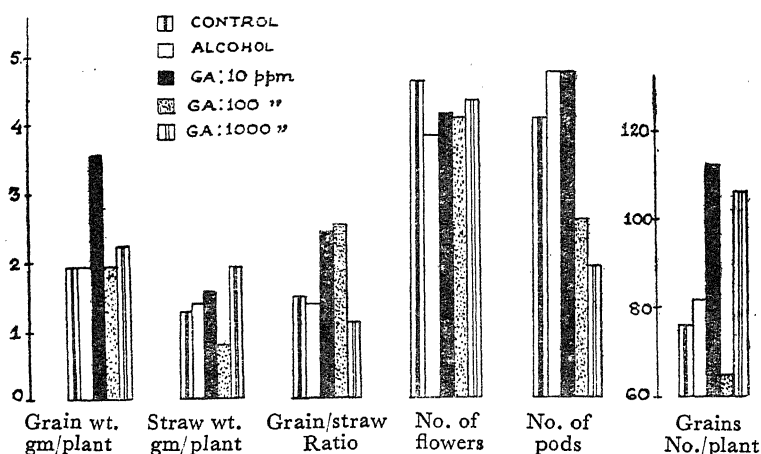


Fig. 1. Effects of gibberellic acid on *Lens esculenta* (Moench)

On an average, the number of internodes increased with age irrespective of the treatments. GA treatments that produce significant effect in this regard were 100 and 1,000 ppm concentrations at one week stage; 10, 100 and 1,000 ppm at 2-week stage, and 100 ppm alone at the 3-week stage. GA concentrations of 10 ppm narrowly missed the significance level at one-week stage (Table 2).

TABLE 2  
Effect of gibberellic acid on the number of internodes of treated shoot of  
*Lens esculenta*. Moench  
(Average No./Plant)

Treatment	Period after treatment (weeks)		
	1	2	3
Control	6.25	10.37	14.00
Alcohol	6.87	12.25	14.25
GA I	7.12	12.75	15.62
GA II	8.25	13.87	17.25
GA III	8.37	13.25	16.62
S.E.	0.479	6.338	1.071
C.D. at 1%	1.324	0.934	2.960
C.D. at 5%	0.981	0.693	2.194

The length of the treated lentil shoot increased significantly under all the treatments at all the stages. A progressive increase in length of the shoot was also noted with the increased GA application (Table 2). GA treatments proved deleterious, though not significantly, for average number of branch/plant.

The effect of the GA application in the number of grains, grain weight and straw produce (per plant basis) showed benefit having accrued specially from 10 ppm concentrations in the first two characters and from 1,000 ppm concentration in the last character (Fig. 1). The effect of GA on total number of pods remained insignificant.

#### Discussion :

GA application to the apex of lentil plant caused the elongation of the 1st, 2nd, 3rd as well as 4th internodes and the response was directly proportional to the concentrations used. The findings are in line with those reported by Marth *et al* (1956) ; Brian and Grove (1951), Singh (1963) ; and Singh *et al* (1964) to some extent. In close agreement with the above, increase in the length of stem was associated with the individual contribution of all the internodes which elongated significantly due to cell extension and division, such an effect has been reported by Lang (1956) and Lona (1956). Increase in number of internodes on treated shoot also seemed, probably to be the outcome of cell division. Lona (1956), and Brian (1958) have also recorded increase in number of internodes on main axis of the treated plant. Identical to the behaviour of wheat reported by Singh (1963) lentil also showed the non-polar nature of GA and also its auxin mediated action. Kuse (1958) offered proof of such an action and Brian (1959) also supported the same.

In the present investigations grain number, its weight and that of straw were positively affected by gibberellic acid application.

#### Summary :

The effect of the application of gibberellic acid at three concentrations, in alcoholic solution applied as micro-drops on one month old seedlings of *Lens esculenta*. Moench. was recorded. The internodes towards the top were more affected than the basal ones. The number of internodes on the treated shoot was significantly greater than the control. The number of grains, grain weight, straw weight were positively yet insignificantly affected by GA application.

#### References :

- Brian, P. W., Elson, G. W., Hemming, H. G. and Radley, M. The plant growth promoting properties of gibberellic acid, a metabolic product of the fungus, *Gibberella fujikuroi*. *Sci. Food Agri.*, 5 : 602-612, 1954.
- Brian, P. W. Gibberellic acid. A new plant hormone controlling growth and flowering. *J. Roy. Soc. Arts. London*, 104 : 425-441, 1958.
- Brian, P. W. and Grove, J. F. Gibberellic acid, *Endeavour*, XV (63) : 161-171, 1957.
- Gray, R. A. Alteration of leaf size and shape and other changes caused by gibberellins in plants. *Am. J. Botany*, 44 : 674-682, 1957.
- Kuse, G. Necessity of auxin for the growth effect of gibberellin. *Bot. Mag., Tokyo*, 71 : 151-159, 1958.
- Lang, A. Stem elongation in rosette plant induced by gibberellic acid. *Naturwiss.* 43 : 257-258, 1956.
- Bolting and flowering in biennial *Hyoscyamus niger* induced by gibberellin. *Plant Physiol. Suppl.*, XXXV, 1956.

- Lona, F. L'azione dell'acido gibberellico sull'accrescimento caulinare di alcune piante erbacee in Condizioni esterne controllate. *Nuovo Giorn. Bot. Italiano*, n.s. **68** : 61-76, 1956.
- Lona, F. and Bocchi, A. Increasing characteristics and development of winter races treated with gibberellic acid. *Riv. Intern. Agr.* **1** (6) : 44-47, 1956.
- Marth, P. C., Audia, W. V. and Mitchel, J. W. Effect of gibberellic acid on growth and development of plants of various genera and species. *Bot. Gaz.* **18** : 106-111, 1956.
- Morgan, D. G. and Mees, G. C. Gibberellic acid and growth of crop plants. *Jour. Agri. Sci.* **50** : 49-59, 1958.
- Meritt, J. M. Gibberellins for Agriculture. *J. Agric. Food Chem.* **6** : 184-187, 1958.
- Sandhu, A. S. and Husain, A. Effect of seed treatment with gibberellic acid on germination and growth of Bajra (*Pennisetum typhoides*). *Indian J. Agron.* **5** : 267-272, 1961.
- Singh, A., Singh, O. S. and Singh, P. N. Effect of pre-soaking *Vigna catjang* seeds in aqueous solution of potassium gibberellate on its subsequent growth, metabolism drought resistance and nodulation. *Proc. Nat. Acad. Sci.*, B, XXXIV, Part III, 1964.
- Singh, A. The growth and Yield of *Triticum aestivum* under the influence of Gibberellic acid. *Proc. Nat. Acad. of Sci.* B, XXXIII, Part IV, 1963.

# VARIATIONS IN PATHOGENICITY OF *PROTOMYCES* *MACROSPORUS* UNG.

By

J. S. GUPTA and S. SINHA

*Botany Department, Agra College, Agra*

[Received on 6th January, 1964]

*Protomyces macrosporus* Ung. causes the stem-gall disease of coriander. The hypertrophies appear on stem, leaves and fruits. The galls contain a mass of chlamydospores. Gupta and Sinha (1963) noted that chlamydospores of the pathogen collected from different localities differ in their morphological characters as indicated by variations in their size, thickness of episporia and diameter of germinated spore-sacs or in, the inter-relationship of these characters. But these differences did not indicate, with any certainty that the pathogen comprises of distinct morphologic forms although biometric categories were evident. The possibility of variations in pathogenicity, as found in large number of parasitic fungi, has, therefore, been investigated. The conventional method of testing host varieties for differences in infection reactions by the pathogen, collected from the various places, was adopted. Seven samples of the fungus, collected from widely separated localities of Uttar Pradesh and one from Patna, have been employed in the experiment. Ten coriander varieties grown in different parts of the country were obtained from the Head, Division of Botany, I. A. R. I., New Delhi.

## Method and Material :

The fungus samples consisted of hypertrophied stem and fruits collected from Meerut, Deoria, Jaunpur, Moradabad, Varanasi, Behraich, Dehra Dun and Patna. The host varieties tested for pathogenicity were : I. C. 4563, I. C. 3634, I. C. 3809, I. C. 3931, I. C. 3925, Koilpatti, and from crops grown in Nagpur, Rewa, Coimbatore and Hyderabad. Seeds were surface sterilized with 0.1% mercuric chloride for two minutes and washed several times with sterilized water. Chlamydospore inoculum of the parasite, obtained by crushing the hypertrophied material, was used in surface contamination of the seeds, the ratio of the seed and inoculum being 1:1 by weight. Contaminated seeds of each variety were sown in sterilized soil in glazed 9" pots. Five seeds were sown in each pot. Sowings for each treatment were made in duplicate. After one month's growth, the seedlings were thinned to three in each pot. Observations were recorded at maturity on the disease intensity of stem out of a rating of 40 points, based on the extent and density of hypertrophy, and adopting the technique developed by the senior author (1954). The values so obtained were converted into percentages and infection reactions were classified into five categories : (a) resistant (1-10%), (b) mild (11-25%), (c) susceptible (26-50%), (d) virulent (51-75%) and (e) highly virulent (76-100%) types.

## Experimental :

The data on percentage disease intensity of stem, obtained in eight samples of the parasite on ten coriander varieties, are included in Table I. Infection types have been based on the percentage disease intensity.

TABLE I  
Percentage disease intensity on stem of various host varieties  
(Mean of 6 plants)

No.	Host varieties	Source of fungus samples							Patna
		Meerut	Deoria	Jaunpur	Morada- bad	Banaras	Behraich	Dehra Dun	
1	I. C. 4563	18.50	10.25	67.75	94.14	32.50	5.75	47.75	16.25
2	I. C. 3634	2.50	23.50	18.25	37.00	21.25	55.25	37.00	37.75
3	I. C. 3809	22.00	61.00	20.25	75.25	12.75	47.50	56.50	16.25
4	I. C. 3931	43.25	30.25	42.75	53.75	10.75	20.00	43.25	49.50
5	I. C. 3925	18.25	9.00	8.25	58.25	15.75	18.25	49.00	50.25
6	Koilpatti	5.00	40.25	13.25	40.00	18.25	24.50	53.25	47.75
7	Nagpur	5.00	30.25	40.25	75.25	78.75	35.75	60.25	47.75
8	Rewa	18.50	43.25	60.00	60.00	49.00	62.50	37.00	31.50
9	Coimbatore	12.50	21.25	41.50	57.50	63.75	45.00	14.50	31.75
10	Hyderabad	12.75	11.50	27.75	59.50	41.25	37.50	18.75	38.25

The results of the reactions indicate generally that a given variety of the host shows different types of infections (% disease intensity) with inocula of different sources and also the inoculum from a particular locality reacts differently with at least some host varieties. Further, some host varieties gave 'resistant' type of reaction (1-10% disease intensity) with certain samples of the parasite, *e.g.*, host varieties I. C. 3634, Koilpatti and Nagpur with inoculum from Meerut; I. C. 3925 with inoculum from Deoria and Jaunpur and I. C. 4563 with inoculum from Behraich. 'Mild' infection (11-25% disease intensity) was obtained in several varieties with a number of fungus samples, *e.g.*, I. C. 4563 with inoculum from Meerut, Deoria and Patna; I. C. 3634 with inoculum from Deoria, Jaunpur and Varanasi. So also was the case in 'susceptible' type of reactions (26-50% disease intensity); I. C. 3931 having a disease intensity range of 26-50% with the inocula from Meerut, Deoria, Jaunpur, Dehra Dun and Patna. 'Virulent' (51-75% disease intensity) and 'highly virulent' (76-100% disease intensity) reactions were shown by the fungus sample from Moradabad on differing varieties of host.

It is further clear from the data in Table 1 that the samples of the parasite can be grouped roughly in three categories with respect to their infection reaction. Moradabad inoculum mostly shows types 4 and 5 (virulent and highly virulent), Meerut 1 and 2 (resistant and mild), and the rest mostly 2 and 3 (mild and susceptible). Thus the parasite can be classified under three varying degrees of pathogenicity.

It may be pointed out, however, that from the theoretical standpoint it cannot be said with any certainty whether physiological forms occur in the parasite, more so due to the incomplete knowledge of cytological behaviour during formation, as well as germination of the chlamydospore. In case chlamydospores have diploid

nuclei, as suggested by Buren (1915) and Fitzpatrick (1930), it is possible that segregation in different types of sporangiospores, capable of infection, may take place. Again, sporangiospores on conjugation form diploid mycelia and subsequently chlamydospores; here combination of different sporangiospore characters might take place. Thus the possibility of hybridization in the course of the life history cannot be ignored. It is, therefore, not possible to explain the differential infection reactions on host varieties by chlamydospores necessarily on the basis of distinct physiologic strains; perhaps the pathogenicity of the sporangiospores on segregation and again on recombination may cause different infection intensities. Similar points were raised by Holton (1930) in his study of bunt of wheat caused by *Tilletia* spp. He stated, "There seems to be evidence that many of the smuts are heterothallic; therefore, chlamydospores would represent the diploid phase. When the spores germinate, there is presumably reduction division and segregation of sporidia into two or more sexual groups. Hybridization would again occur before chlamydospores could be produced on the plants. If this be true, perhaps only monosporidial lines would be designated properly as physiologic forms, and chlamydospores would be hybrids between forms". Considering the practical aspect of the problem he conducted his studies on physiologic specialization by noting degree of virulence caused by the samples of the bunt on different host varieties. On the same lines, in the present study, disease intensities caused by different samples of the parasite from widely separated localities were assessed on ten host varieties and results were analysed on the basis of high or low disease intensity. Although the existence of different physiologic forms in *Protomyces macrosporus* Ung. may not be considered with any certainty, yet the data yield valuable information on susceptibility or resistance of various coriander varieties to collections of the parasite from different localities. The problem has further scope for investigation.

#### Summary and Conclusions :

Following the technique adopted by the senior author, infection-reactions on ten coriander varieties in respect of eight collections of *Protomyces macrosporus* Ung. from localities widely separated, were recorded in order to see the variations of pathogenicity in the parasite, if any.

The results indicate that a given variety of the host shows different reaction types within the same inoculum and also a given inoculum reacts differently with some of the host varieties under study. An analysis of reactions on the host varieties by the parasite indicates that the samples of the parasite are distinct and can be grouped roughly in three categories. Inoculum from Moradabad shows types 3, 4 and 5 (susceptible, virulent and highly virulent). Meerut reacts under type 1 and 2 (resistant and mild) and the rest mostly under types 2 and 3 (mild and susceptible) thus indicating the probability of existence of three varying strains of pathogenicity. But a complicating factor appears to be associated with the probable hybrid nature of the chlamydospores.

The present data appears in line with the observations on biometry of chlamydospores of the above parasite wherein, within the eight samples of the parasite three or four groups were recognized earlier.

#### Acknowledgement :

The authors express their sincere thanks to the Head of Division of Botany, I. A. R. I., New Delhi, for supplying certain improved varieties of coriander. Thanks are also due to other friends who helped in the collection of the material of the parasite from different localities.

**References :**

- \*Buren, Gunther von Die Schweizerischen *Protomycetacean* mit besonderer Berücksichtigung ihrer Entwicklungsgeschichte und Biologie. Beitrage Kryptogamenflora Schweiz, 5 : 1-95, 1915.
- Fitzpatrick, H. M. The lower fungi. McGraw Hill Book Co., N. Y. 1930.
- Gupta, J. S. Disease appraisal of stem-gall of *Coriandrum sativum* L. *Indian Phytopath.*, 7 : 53-60, 1954.
- Gupta, J. S. and S. Sinha, Biometric groupings in *Protomyces macrosporus* Ung. causing stem-gall disease of coriander. *Proc. Nat. Acad. Sci. India*, Sec. B, 33 : 507, 510, 1963.

---

\*Original not seen ; source from 'The lower fungi' by Fitzpatrick, H. M.

# ON A STRIGEID METACERCARIA FROM *HETEROPNEUSTUS FOSSILIS* BLOCH ('SINGHI')

By

B. P. PANDE, B. B. BHATIA and P. RAI

Department of Parasitology, U. P. College of Veterinary Science  
and Animal Husbandry, Mathura

[Received on 6th July, 1963]

## Introduction :

Amongst the recognised strigeid larval genera, *Diplostomulum* Brandes, 1892, *Neascus* Hughes, 1927, and *Tetracotyle* Fillipi, 1859 have been reported from some of our fresh-water fishes. A *Diplostomulum* larva was, for the first time, recorded from the fingerlings of *Catla catla* by Ganpati and Hanumantha Rao (1954). Subsequently, in 1955 they found metacercarial cysts in two other fishes, *Labeo calbasu* and *Nuria danrica* from fisheries pond. The other available reports on diplostomula are those of Abraham and Anantaraman (1955) who described black cysts, under the skin, in the fingerlings of *C. catla* and of Singh, R. N. (1955) who gave an account of a new species, *D. pigmentata*, occurring in black-pigmented cysts in muscles of *C. catla*, *Cirrhina mrigala* and *Labeo rohita*. These reports are either based on high mortalities or heavy infestations encountered. Singh, K. S. (1957), evidently not aware of these papers, described another new species, *D. elongatus*, collected from transparent cysts found loosely attached to the mesentery in *Trichogaster fasciatus*. Recently Ganpati and Hanumantha Rao (1962), extending their earlier observations to some of the life history stages including metacercaria to adult, have identified the young stages as belonging to *Diplostomulum ketupanensis* Vidyarthi, 1937. Referring to the form described by Abraham and Anantaraman as identical to the one described by them, these authors have also mentioned that *D. pigmentata* Singh, 1956 was also similar to it.

## Material and Methods :

Different developmental forms of a diplostomulum metacercaria were collected from small intestine, body cavity, and musculature of *Heteropneustus fossilis* Bloch ('Singhi'). Fifteen specimens of this fish were available during the teaching session 1961-62 for examination. The intestine, on two occasions, yielded numerous immature forms and somewhat more developed specimens were once collected from the body cavity around the heart. The musculature, in two cases, revealed white cysts which, after extraction and subsequent teasing, yielded the fully developed forms. These different stages in the present collection were studied alive, suitably fixed, and subsequently stained and mounted. Primary excretory system could not be traced. Some of the preserved specimens were also serially cut and stained for details of the anatomy.

## Observations :

Specimens, collected from intestine and body cavity (Fig. 1), exhibited a finely striated body full of calcareous corpuscles and with a ventral concavity. Lateral sucking cups and smaller hind-body were only poorly differentiated. Acetabulum, slightly smaller than oral sucker, was located just behind the

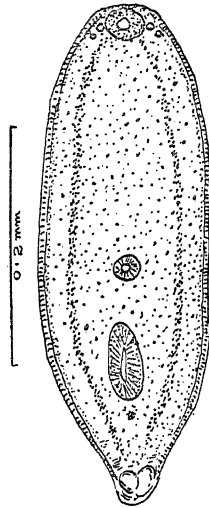


Fig. 1

(Developing diplostomulum). Entire mount showing the two suckers, hold-fast organ, genital rudiment and region of bursa-capulatrix.

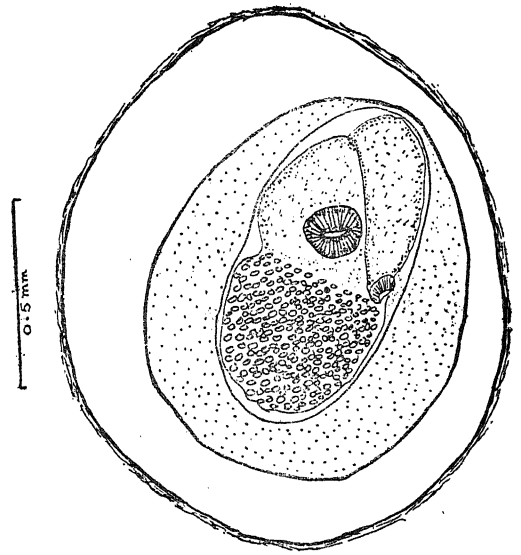


Fig. 2

Metacercarial cyst showing the outer and inner walls with the harboured stage.

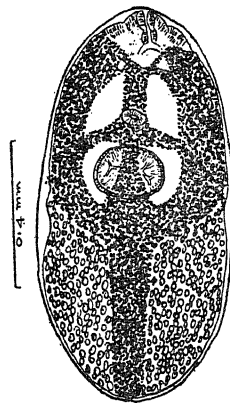


Fig. 3

A metacercaria removed from the cyst and showing oral sucker, pharynx, intestinal caeca, lateral sucking cups, acetabulum, hold-fast organ and secondary excretory system.

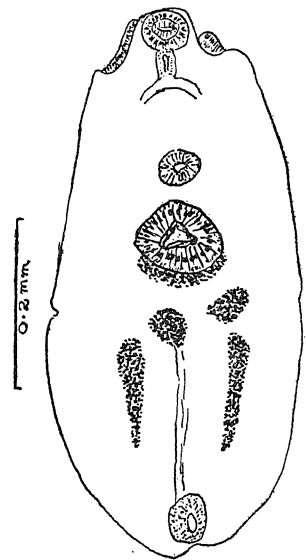


Fig. 4

Permanent stained mount showing oral sucker, pharynx, intestinal bifurcation, acetabulum, hold-fast organ, lateral sucking cups in the fore-body and genital rudiments with bursa copulatrix in the hind-body.

middle of the body. Genital rudiment and bursa copulatrix could be observed in hind-body with the hold-fast organ in the middle of the posterior half of the body. A pharynx and intestinal caeca were seen only in sections. Different measurements recorded are :—length 0.4–0.52 mm., width 0.15–0.24 mm., oral sucker 0.028–0.032 × 0.032–0.036 mm., acetabulum 0.024–0.028 × 0.28–0.032 mm., hold-fast organ 0.04–0.048 × 0.06–0.68 mm.

Cysts (Fig. 2), located mostly in the muscles of the trunk, were whitish in colour and in two parts—the outer fibrous part of host origin measured 1.22–1.56 × 0.87–0.97 mm. in size and the inner, full of fluid around the contained parasite, was 0.85–0.9 × 0.35–0.44 mm. in dimensions. The juvenile stage exhibited two distinct but nearly equal regions—foliaceous fore-body with oral sucker, lateral sucking cups, acetabulum and hold-fast organ and hind-body full of dark calcareous granules of 0.004–0.006 mm. in size. On teasing the cyst, the parasite performed movements in normal saline and after 4–6 hours the internal anatomy, with essential details of its secondary excretory system, was evident under cover-glass pressure (Fig. 3).

The specimens measured 1.19–1.28 mm. in length and 0.51–0.58 mm. in breadth, with the fore-body of 0.61–0.66 mm. and the hind-body 0.58–0.62 mm. long. Sub-terminal and almost circular oral sucker measured 0.08 × 0.81 mm. in size. Lateral sucking cups were shallow in form and 0.06 × 0.12 mm. in size. Pharynx measured 0.036 × 0.056 mm., directly dividing into intestinal caeca. Acetabulum, lying nearly at  $\frac{1}{4}$ th of the body length from the anterior end, measured 0.052 × 0.1 mm. in size. The nearly spherical hold-fast organ, situated just behind the acetabulum and 0.12 × 0.192 mm. in size, exhibited a prominent glandular area particularly in its posterior region. Intestinal caeca were not visible on account of the darker contents of the excretory system and the calcareous granules. Secondary excretory system well-developed with a large bladder located in the hind-body and connected with a median and two lateral trunks extending anteriorly to near the pharynx and with three transverse commissures, one between the acetabulum and hold-fast organ, a second just behind intestinal bifurcation and the third anterior to it in the region of the lateral sucking cups (Fig. 3). The genital rudiments, in the hind-body, are represented by four well-defined masses, two on each side, consisting of a somewhat rounded anterior and an elongated posterior group—the former representing ovary and Mehlis' gland area and latter the two testes. Bursa copulatrix, at the posterior end of the hind-body, received a tubular duct-like structure. Spines, over the body, were absent.

#### Remarks :

The present material on account of its aspinose cuticle, non-pigmented character of its cysts, nearly equal size of the fore-and hind-body and absence of an oesophagus appears distinct from the metacercarial forms studied by Ganpati and Hanumantha Rao, Abraham and Anantaraman, and Singh, R. N. This form, from the muscles of *H. fossilis* is, therefore, assigned tentatively to a new species of *Diplostomulum*, *D. singhi* n.sp. It can easily be distinguished from *D. elongatus* Singh, 1957 which, inside transparent cysts, occurs loosely attached to the mesentery, is much smaller in size and lacks entirely the calcareous granules. The forms, recovered from intestine and body cavity, were distinctly younger in development and apparently represented the stage prior to its entry into the musculature where the characteristic metacercarial cysts subsequently develop. Question of validity of the various diplostomulae and the allied larval forms in

strigeids can best be settled after work on the life cycle studies has been conducted and the adult forms, developing from them, are available for comparison.

**Summary :**

*Heteropneustus fossilis* is recorded as the host of a diplostomulum assigned to a new species, *Diplostomulum singhi*. The metacercarial stage in musculature and the earlier developing forms, from intestine and body cavity, have been described. Previous work on other Indian representatives has been reviewed.

**Acknowledgement :**

Thanks are due to Prof. S. K. Talapatra for supplying the specimens of fish and to the Principal of the College for facilities provided.

**References :**

- Abraham, F. G. and Anantaraman, M. Black Grub Infection in *Catla catla*. *Nature Lond.*, **175** : 127, 1955.
- Ganpati, P. N. and Hanumantha Rao, K. On Black-grub disease in fresh water carp, *Catla catla*. *Curr. Sci.*, **23** (12) : 401-402, 1954.
- On the occurrence of metacercarial cysts of a diplostome (Trematoda) in freshwater fishes. *Proc. Indian Sci. Cong.*, Pt. **3** : 285-286, 1955.
- Ecological and life-history studies on a strigeid metacercaria (Trematoda: Diplostomatidae) from fresh water fishes of Andhra Pradesh. *Parasitol.*, **52** (3/4) : 519-525, 1962.
- Singh, K. S. *Diplostomulum elongatus* n.sp. (Trematoda), from a fresh water fish, *Trichogaster fasciatus* from India. *J. Parasit.*, **43** (3) : 371-373, 1957.
- Singh, R. N. Studies on a new strigeid metacercaria parasitic in cyprinoid fishes. *Proc. Nat. Acad. Sci. India.*, **26** Sec. B (4) : 255-263, 1956.

# SOME ASPECTS OF THE BIOLOGY OF THE THREE SPECIES OF THE GENUS *ONYCHIURUS* (COLLEMBOLA)

By

D. K. CHOUDHURI

Department of Zoology, University of Kalyani, Faculty of Science, West Bengal

[Received on 23rd November, 1963]

## Introduction :

Amongst the Collembola *Sminthurus viridis* (Lucerne flea) because of its relatively great agricultural importance in Australia and Tasmania has attracted the attention of many workers and most of the work on the biology of Collembola refers to this species. Very little except a brief account of the biology of *Onychiurus armatus* by Handschin (1929) is known on the biology of *Onychiurus* in spite of the damage caused by various species of this genus, reported by several investigators in recent years Paclt (1956). Lack of information on the biology of *Onychiurus* has prompted the present author to undertake some biological investigations on the 3 species, *O. fimatus* Gisin, *O. parthenogeneticus* Choudhuri and *O. imperfectus* Denis.

## Material and Method :

The specimens were collected by extracting them from the samples of soils and moss by means of a modified Tulgren funnel. Cultures were built up and maintained in the laboratory in small glass vivaria in the way suggested by Choudhuri (1960).

## Biology :

**Behaviour :** The three species are found in the field in company with many other collembolans. In captivity they can be distinguished from each other by the locomotory behaviour characteristic of each species. This becomes more distinct when they are disturbed. *O. fimatus* when disturbed is seen to run about with more agility than the other two. *O. parthenogeneticus* is a relatively slow-walker ; but while walking all three species move with their antennal tips rapidly moving in the horizontal plane and intermittently tapping on the substratum with the apex of the antenna. Frequently they move up and down along the vertical sides of the containers and also on the under-surface of the lid. Besides, when any part of the body is touched by a needle *O. fimatus* instantaneously bends its body to form an arch and remain immobile in that posture for some time after which it regains its original orientation. *O. imperfectus* simply bends its head and firmly fixes its antenna against the substratum, quickly regaining its normal orientation whereas *O. parthenogeneticus* does not seem to respond to it.

**Oviposition :** In Collembola oviposition has been described by many workers since Lubbock (1873). Notable amongst them are Macnamara (1919), Holdaway (1927), Ripper (1930), Davidson (1932) and MacLagan (1932) ; none of these authors dealt with *Onychiurus*.

Egg-laying has been observed on several occasions in each of the three species, both by day and night and is found to be essentially the same in all. The eggs

are usually laid in batches, the size of which varies from species to species and depends partly on temperature and partly on the age of the female concerned. In many cases it has been noticed that if the female is disturbed, she moves to another place after having laid only a subnormal number of eggs and starts the process anew. Just before oviposition the female depresses her head and retracts the last abdominal segment until it is completely hidden within the body. Consequently the abdomen assumes a U-shape with the genital aperture lowered in order to facilitate oviposition. Simultaneously the first egg makes its appearance through the genital aperture, adheres for a while and is then placed on the substratum. As soon as the first egg is dropped the second one comes out, similarly remains attached for a short time before it is placed either on or by the side of the previous one. Each time an egg is ejected, the abdomen gives a slight jerking movement to oviposit the sticky egg from the genital aperture. Otherwise the general posture of the female remains unaltered throughout the process which continues in the three species for an average period of 37, 35 and 46 minutes respectively. The maximum number of eggs laid in each batch under optimum conditions is about 18, 16 and 18 respectively.

*Egg-development* : At 24°C the thin and smooth chorion in the three species breaks on the 4th, 4th and 6th day respectively, in the form of an equatorial slit. This slit in each case becomes gradually more pronounced until the chorion is completely separated into two halves which remain attached to the 1st cuticle in the form of two polar caps. With the breaking of the chorion the rough corrugated surface of the cuticle I becomes exposed and can be distinctly observed even to the naked eye. The gradual increase in size in the species owing to the progressive development of the embryo continues upto the 8th, 8th and 11th day respectively (Table 1).

TABLE 1  
Showing the average daily measurements of 10 eggs

Days	Species		
	<i>O. fimatus</i>	<i>O. parthenogeneticus</i>	<i>O. imperfectus</i>
1	1.29	1.10	1.17
2	1.31	1.11	1.19
3	1.34	1.14	1.21
4	1.38	1.17	1.23
5	1.44	1.22	1.26
6	1.49	1.27	1.29
7	1.51	1.30	1.34
8	1.53	1.32	1.38
9	1.53	1.32	1.41
10			1.43
11			1.45
12			1.45

*Ecdysis* : This process is similar in *O. fimatus*, *O. parthenogeneticus* and *O. imperfectus*. Just prior to the emergence of the I instar the cuticle I splits around an equator in the plane vertical to the longitudinal axis of the embryo. Then, by

pulling its body backwards and forwards in quick succession the I instar liberates itself from the crescentic groove of the cuticle I. Immediately after hatching the young individual starts walking about; the whole process takes only 2-3 minutes to complete under favourable conditions.

*Number of instars*: As the collembolans do not stop moulting with the attainment of maturity one of the first things which requires investigation is the number of the instars and the approximate time taken by each instar. For this purpose individuals of the I instar were kept and reared singly and each one was examined twice daily for the cast skin.

TABLE 2  
Showing the application of Dyar's Law  
*O. fimatus*

Average ratio of increase = 1.15

Observed width in microunit	Ratio of increase	Theoretical width (as calculated from Dyar's factor)	Stages
0.95	—	—	I Instar
1.08	1.137	$0.95 \times 1.15 = 1.092$	II „
1.24	1.140	$1.08 \times 1.15 = 1.256$	III „
1.44	1.160	$1.24 \times 1.15 = 1.450$	IV „
1.69	1.173	$1.44 \times 1.15 = 1.670$	V „
1.89	1.112	$1.69 \times 1.15 = 1.920$	VI „
2.20	1.164	$1.89 \times 1.15 = 2.208$	Adult

*O. parthenogeneticus*

Average ratio of increase = 1.143

0.90	—	—	I Instar
1.01		$0.90 \times 1.143 = 1.028$	II „
1.18		$1.01 \times 1.143 = 1.175$	III „
1.34		$1.18 \times 1.143 = 1.340$	IV „
1.51		$1.34 \times 1.143 = 1.510$	V „
1.74		$1.51 \times 1.143 = 1.740$	Adult

*O. imperfectus*

Average ratio of increase = 1.145

0.97	—	—	I Instar
1.12	1.154	$0.97 \times 1.145 = 1.107$	II „
1.30	1.160	$1.12 \times 1.145 = 1.271$	III „
1.48	1.139	$1.30 \times 1.145 = 1.455$	IV „
1.72	1.160	$1.48 \times 1.145 = 1.670$	V „
1.94	1.220	$1.72 \times 1.145 = 1.912$	VI „
2.20	1.134	$1.94 \times 1.145 = 2.189$	Adult

Comparing the exuvium with the morphological findings on each instar it is found that the three species in order to become adults pass through 6, 5 and 6 stages respectively, each morphologically distinct from others. The adult, here, represents the stage after which no morphological change is associated with the change of skin.

This finding was finally checked by applying Dyar's law (1890) to the average measurements of the width of the head of 20 individuals of each instar, the results of which are presented in Table 2.

It will be observed that Dyar's law is applicable to some species of *Onychiurus* and the approximation of the observed to the calculated measurements in all three species is sufficient to show that an ecdysis has not been overlooked.

*Ecdysis* : Just prior to ecdysis the insect, suddenly becomes quiescent for a minute or two after which it lowers its head, arranges its hind legs in such a way that they are almost parallel with the long axis of the abdomen; it implants the middle legs firmly at right angles to the body and extends forward the front pair of legs. As soon as this posture is secured the insect starts moving its body to and fro along the long axis until the cuticle at the mesothorax splits. At this stage the head is flexed so much that the antennae almost touch the front legs and the prothorax appears as the most anterior part of the body. Thereafter, by extending the thorax upwards the animal liberates its head and antennae and then begins to push away the ruptured cuticle from the thorax and abdomen with the tip of its antennae until the remaining legs and the anterior part of the abdomen are freed. At this stage, the insect rests for a little while but soon rotates the raised tip of the abdomen more than once and finally it is seen to walk away as the tip of the abdomen slides out from the exuvium. When food is available it starts feeding immediately after ecdysis, otherwise it is frequently observed to eat the cast skin. This process in the three species lasts for about 10, 12 and 18 minutes respectively. Moulting occurs as long as the insect survives and at 24°C the three species undergo a total number of about 28, 24 and 17 moults respectively (Choudhuri, 1963).

*Duration of instar* : At  $20 \pm 2^\circ\text{C}$  and with 100% R. H. the duration of the respective instars in the three species is approximately as given in Table 3.

TABLE 3  
Showing the time covered by successive instar in days at  $20 \pm 2^\circ\text{C}$

Instars	<i>O. fimatus</i>		<i>O. parthenogeneticus</i>	<i>O. imperfectus</i>	
	Male	Female	Female	Male	Female
I	4.5	4.6	5.8	6.5	6.5
II	5.0	5.0	6.0	6.7	6.8
III	5.4	5.4	6.1	6.9	6.9
IV	5.8	5.9	6.1	7.0	7.1
V	8.2	8.2	6.2	7.2	7.1
VI	6.3	6.7	6.2 (Adult)	7.1	7.2
Adult	7.1	7.2		7.3	7.4

It is indicated that there is an increase in the interval with the advancement of the post embryonic development, especially in *O. fimatus*. The total time spent by the males to reach the adult stage does not differ significantly from that of the female in either *O. fimatus* or *O. imperfectus*. The relatively larger duration of the V instar of *O. fimatus* may be owing to the onset of sexual maturity at this instar. The duration of the life-cycle from the time of hatching to the adult stage in the three species is 36, 30 and 41 days respectively. The development-period in the egg stage of the three species under the same conditions is approximately 14.5, 15.6 and 17.2 days respectively (Choudhuri, 1963), bringing the total length of the life-cycle from egg to adult in the three species to about 50, 46 and 58 days respectively.

**Parthenogenesis :** 25 individuals of each species immediately after they emerged were isolated one in each freshly prepared and flame-sterilized vivarium at each of the 4 different temperatures i.e.  $14 \pm 1^\circ\text{C}$ ,  $20 \pm 2^\circ\text{C}$ ,  $24^\circ\text{C}$  and  $28^\circ\text{C}$ . At all temperatures, the individuals belonging to *O. parthenogeneticus* laid eggs which eventually developed into young individuals. 25 members of the first generation were similarly kept isolated and ultimately each of them laid eggs which in their turn developed into the offsprings of the second generation. Microscopic examinations of the specimens at random from 10 successive generations confirmed the occurrence of complete thelytokous parthenogenesis. No parthenogenesis was found in case of the other two species.

### Discussion :

The eggs of *Onychiurus* have been described by Handschin (1926) who has given figures of the eggs of *O. armatus* (Tullb.) and *O. fimatus* (L.). In case of the latter Handschin showed a number of circular pits on the surface of the eggs. No such structures were found in *O. imperfectus* although a member of the same group of species. Assuming Handschin's findings as correct, it is interesting to note that the egg provides a further character to separate closely related species which differ from one another by only one or two morphological criteria.

The process of oviposition as reported here follows more or less the pattern exhibited by *Sminthurus viridis*, but in *Onychiurus* no faeces is passed from the anus at the time of oviposition.

The change of colour during the development of the egg has not been recorded so far in Collembola and it may be the result of an interaction of the substance coating the egg with air, since the eggs dissected from the females are white in colour and those which are kept submerged under water as soon as they are laid, do not change colour. Such a change in colour is of common occurrence among insects and has recently been reported by Sprague (1956) in *Hydrometra martini*. The rupture of chorion in the form of an equatorial split and gradual increase in size of the eggs with the growth of the embryo confirms the observation of the earlier workers, Holdaway (1927), MacLagan (1932), Davidson (1932) and Tiegs (1942).

The process of eclosion is rapid and uniform. From the time the I instar walks away from the egg-shell its activities closely resemble to those of the adult. This is especially true of locomotion, moulting and feeding.

The process of ecdysis in Collembola has previously been mentioned by MacLagan (1932) and Strebel (1932). Handschin (1926) was the first to describe and illustrate the moulting behaviour of *O. armatus* (Tullb.). According to him just prior to ecdysis the insects become absolutely motionless and maintain for some time a typical posture (*vide* P. 25, 37 ; Fig. 27) with head and abdomen curved upward.

Then as a result of to and fro movement of the body the skin becomes ruptured between head and thorax. Finally Handschin remarked that after coming out of the old skin the young animal was frequently seen to eat the cast skin. Subsequently, MacLagan (1932) confirmed the habit of eating the cast skin in *Sminthurus viridis*. The description of ecdysis presented here differs from that of Handschin in two respects i.e. (1) none of the species observed displays any such posture prior to moulting and (2) none of the three species was seen to eat the cast skin when food was made available. This behaviour has been found to occur only in the absence of food from the culture jar and feeding seems to be essential immediately after moulting. Starved individuals not only eat their cast skin but also their own eggs and in one instance the eggs of the mite, *Hermannia gibba* (Koch).

It has already been said that the protracted period in the V instar of *O. fimatus* seems to be associated with the attainment of the sexual maturity. The slowing down of growth with the onset of oviposition has already been reported by MacLagan (1932) in *S. viridis*. Oviposition does not interfere with growth in case of the other two species of *Onychiurus*.

One of the most interesting observations in the present investigation is the parthenogenesis in one species of *Onychiurus*. Handschin (1932) on the basis of Lindenmann's (1950) rearing experiments has noted the possibility of parthenogenesis in Collembola. Schaller (1953) while confirming Strebel (1932 and 1938), who precluded the possibility of parthenogenesis in Collembola, remarks that the females which show apparent parthenogenesis, in fact may have been contaminated by the sperms during the preoviposition period and he suggests, as a result of his observations, two possible ways of contamination, e.g., (1) along with the food and (2) when the females come in contact with the spermatophores. In the perspective of Lindenmann's experiments Schaller's opinion can be justified, to some extent as follows :

(1) Lindenmann's experimental procedure does not eliminate the possibility of contamination of sperms in the way Schaller suggests, (2) Isolation of 30 day old individuals does not guarantee parthenogenesis because at least some Collembola lay the first batch of eggs within that age-limit. Complete thelytokous parthenogenesis in *O. parthenogeneticus* confirmed experimentally through many generations is reported here for the first time.

#### Summary :

Biological observations on the three species of *Onychiurus* such as *O. fimatus*, *O. parthenogeneticus*, and *O. imperfectus* representatives of the "group species", namely, *armatus*, *hortensis* and *finetarius* respectively reveal that (1) oviposition is never accompanied by defaecation as in some other Collembolans. (2) Egg-colour which differs species to species gradually deepens with the development of eggs. (3) Only the starved individuals eat their exuviae and sometimes eggs immediately after moulting. (4) Dyar's law is applicable to them. (5) Growth is slowed down with the onset of oviposition in some species. Besides, the phenomenon of parthenogenesis in Collembola is reported for the first time. Some features of behaviour as regards orientation, oviposition and ecdysis are also mentioned.

## References :

- Choudhuri, D. K. Influence of temperature on the development of *O. furciferus* (Börner) and its mathematical representation. *Proc. Zool. Soc.*, **13**: 123-128, 1960.
- Temperature and its effect on the three species of the genus *Onychiurus*: Collembola. *Proc. Zool. Soc.*, **16**: 97-117, 1963.
- Davidson, J. Factors affecting oviposition of *Sminthurus viridis* L. (Collembola). *Aust. J. exp. Biol. med. Sci.*, **10**: 1-16, 1932.
- Dyar, H. G. The number of moults of Lepidopterous larvae. *Psyche*, **5**: 420-422, 1890.
- Handschin, E. Collembola-Springschwänze. In: Schulze, *Biol. der Tiere Dtschl.*, **25** (20): 7-56, 1926.
- Die Bedeutung der postembryonalen Entwicklung für die *Protomorpha* (Collembolen) *Congr. int. Entomol. I* (1951) *Amsterdam Trans.*, **1**: 235-240, 1953.
- Holdaway, F. G. The bionomics of *Sminthurus viridis* Linn, of South Australian lucerne flea, Common. Australia, *Counc. Sci. and Ind. Res. Pamphl.*, **4**: 1-23, 1927.
- Lindenmann, W. Untersuchungen zur postembryonalen Entwicklung schweizerischer Orchesellen. *Rev. Suisse. Zool.*, **57**: 353-428, 1950.
- Lubbock, J. Monograph of the Collembola and Thysanura. *Ray. Soc.*, pp. 276, 1873.
- MacLagan, D. S. An ecological study of the "lucerne flea" (*Sminthurus viridis* L.) I-II. *Bull. ent. Res.*, **23**: 101-190, 1932.
- Macnamara, C. Remarks on Collembola. *Canad. Ent.*, **52**: 73-271, 1919.
- Pact, J. Biologie der primär flügellosen Insekten, 1956.
- Ripper, W. Champignon-springschwänze. Biologie und Bekämpfung von *Hypogastrura manubrialis* Tullb. *Z. angew. Ent.*, **16**: 546-584, 1930.
- Schaller, F. Untersuchungen zur Fortpflanzungsbiologie arthropleoner Collembolen. *Z. Morph. Ökol. Tiere.*, **41**, 265-277, 1953.
- Sprague, B. The biology and morphology of *Hydrometra martini* Kirkaldy. *Bull. Sci. Univ. Kansas.*, **38**: 579-693, 1956.
- Strebel, O. Beiträge zur Biologie, Ökologie und Physiologie einheimischer Collembolen. *Z. Morph. Ökol. Tiere.*, **25**: 31-153, 1932.
- Biologische Studien an einheimischen Collembolen. III. Zur Biologie des *Tomocerus vulgaris* Tullb., *Konowia.*, **17**: 272-291, 1938.
- Tiegs, O. W. The "dorsal organ" of Collembolen embryos. *Quart. J. Micr. Sci.*, **83**: 153-170, 1942.

# EFFECT OF GRAZING ON THREE GRASSES AND FIVE FORBS GROWING ON THE GROUNDS OF BANARAS HINDU UNIVERSITY

By

HARSHWARDHAN R. SANT

*Botany Department, Banaras Hindu University, Varanasi-5*

[Received on 18th February, 1964]

The grazing grounds within the campus of Banaras Hindu University are grouped for this study into three types viz., (1) protected grounds, (2) medium grazed grounds, and (3) overgrazed grounds (Sant, 1961). Representative plants of *Alysicarpus longifolia*, *A. monilifer* DC., *Boerhaavia diffusa* L., *Digitaria sanguinalis*, Scop., *Desmodium triflorum* DC., *Echinochloa colona* Link., *Setaria glauca* Beau. and *Vernonia cinera* Less., from each field have been studied for growth form and behaviour. Figures 1-8 give their photographs.

The relevant measurements for growth are recorded in Table I.

TABLE I

*Average height, spread and fresh weight measurements of grasses and forbs growing in Banaras Hindu University*

S. No.	Plant species	**Av. Height in cm			**Av. Spread in cm.			**Av. Fresh weight in g.		
		*P	*M	*O	*P	*M	*O	*P	*M	*O
1	<i>Alysicarpus longifolia</i>	34.6	34.0	20.0	11.5	14.5	8.2	2.6	3.2	2.2
2	<i>Alysicarpus monilifer</i>	2.4	1.5	1.0	20.6	42.1	22.5	1.5	8.0	5.6
3	<i>Boerhaavia diffusa</i>	25.0	15.1	10.0	62.0	50.0	30.0	10.5	6.2	2.5
4	<i>Digitaria sanguinalis</i>	94.5	55.2	16.5	40.0	15.0	12.0	3.8	1.8	1.5
5	<i>Desmodium triflorum</i>	1.2	—	0.8	46.5	—	7.2	1.6	—	0.8
6	<i>Echinochloa colona</i>	93.8	37.0	12.0	30.0	7.5	25.0	5.0	2.6	3.2
7	<i>Setaria glauca</i>	95.0	51.5	35.3	9.1	3.8	6.2	38.0	3.0	4.5
8	<i>Vernonia cinera</i>	40.0	21.0	4.5	1.5	6.5	3.8	1.2	1.0	0.8

\*\*Averages are based on 90 counts per protected and medium-grazed fields and 120 counts per overgrazed field.

\*P = Protected field, M = Medium grazed field, O = Overgrazed field.



Fig. 1. *Alysicarpus longifolia* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Medium grazed field, 3 = Overgrazed field.

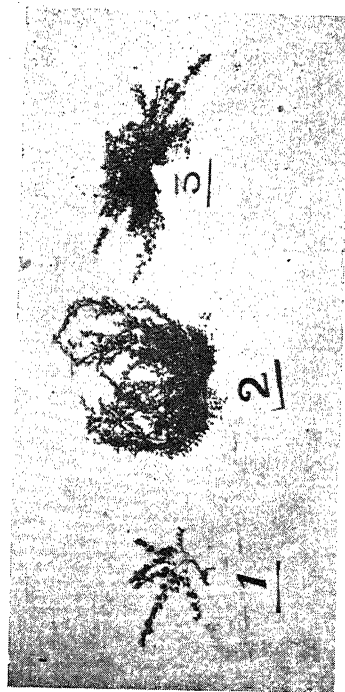


Fig. 2. *Alysicarpus monilifer* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Medium grazed field, 3 = Overgrazed field.



Fig. 3. *Boerhaavia diffusa* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Medium grazed field and 3 = Overgrazed field.

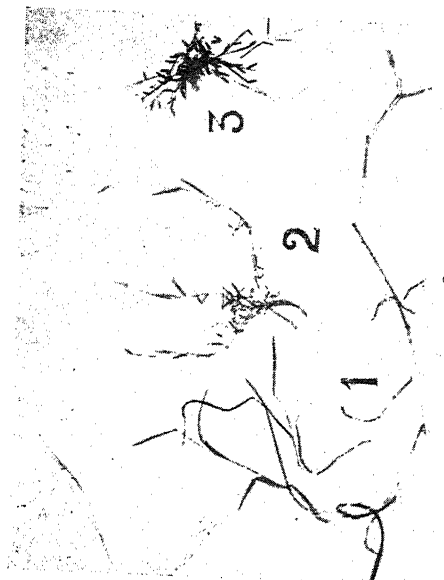


Fig. 4. *Digitaria sanguinalis* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Medium grazed field and 3 = Overgrazed field.



Fig. 5. *Desmodium triflorum* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Mediumgrazed field.

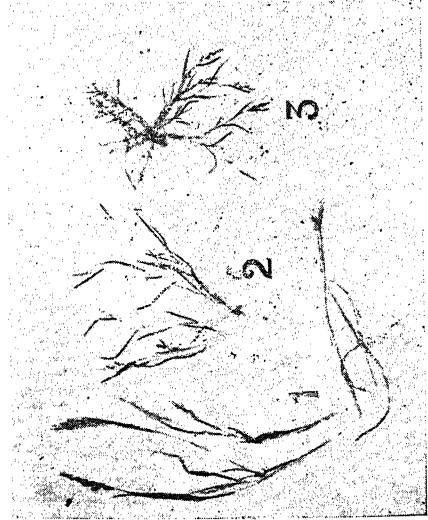


Fig. 6. *Echinochloa colona* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Mediumgrazed field and 3 = Overgrazed field.



Fig. 7. *Setaria glauca* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Mediumgrazed field and 3 = Overgrazed field.



Fig. 8. *Vernonia cinerea* showing variation in growth form in relation to grazing intensities. 1 = Protected field, 2 = Mediumgrazed field and 3 = Overgrazed field.

It is seen from the above table that grazing reduces the height of all the plants. But they grow to spread more in the medium grazed fields in the case of *Alysicarpus longifolia*, *A. monilifer*, DC, and *Vernonia cinera* Less. However, grazing reduces also the spread of *Boerhaavia diffusa* L., *Digitaria sanguinalis* Scop., and *Desmodium triflorum* DC., *Echinochloa colona* Link., and *Setaria glauca* Beau., on the other hand spreads equally in the protected and overgrazed fields. The weight of the plants is in proportion of its spread.

#### Discussion :

It is seen that the height of all the plants decreases as the grazing intensity increases. Branson (1953) presented data which showed that the height to which growing points in grasses was elevated above the ground was related to resistance to grazing. Much of the work listed under vigor in that paper also has application in studying, the differential response of the species to grazing.

Further height of important forage plants is the best indicator of the time when ranges are ready for grazing (Costello and Price, 1939, and Craddock and Forsting, 1938).

It is interesting to note that as soon as the grazing intensities is increased certain plants like *Alysicarpus longifolia*, *A. monilifer* DC., and *Vernonia cinera* Less., show increased spread in medium grazed fields. In the case of *Boerhaavia diffusa* L., *Digitaria sanguinalis* Scop., and *Desmodium triflorum* DC., the spread is reduced due to grazing. *Echinochloa colona* Link., and *Setaria glauca* Beau., has a balancing power in the protected and overgrazed fields.

#### Acknowledgements :

I am deeply indebted to Dr. R. Misra, F.N.I., Professor and Head of the Department of Botany, Banaras Hindu University, Varanasi, for valuable guidance and for kindly going through the manuscript and for helpful suggestions. I am also thankful to the Government of India for providing me with financial assistance in the form of Research Scholarship.

#### References :

- Branson, F. A. Two new factors affecting resistance of grasses to grazing. *Jour. Range. Management*, 6 : 165-71, 1953.
- Costello, D. F. and Price R. Weather and plant development data as determinants of grazing periods on mountain range. *U. S. Dept. Agri. Tech. Bull.*, 686 : 30 p., 1939.
- Craddock, G. W. and Forsting, C. L. The influence of climate and grazing on spring fall Sheep range in Southern Idaho. *U. S. Dept. Agri. Tech. Bull.*, 600 : 42 p., 1938.
- Sant, H. R. A study of the reproductive capacity of some grasses and forbs of the grounds of the Banaras Hindu University. *Ph.D. Thesis of B. H. University*, 1961.

TAXONOMIC OBSERVATIONS ON THE BRITISH SPECIES OF THE  
*ARMATUS* AND *FIMETARIUS* GROUPS OF THE GENUS  
*ONYCHIURUS* (COLLEMBOLA : ONYCHIURIDAE)

By

D. K. CHOUDHURI

*Entomological Laboratory, University of Kalyani, West Bengal*

[Received on 21st January, 1964]

**Present position of *Onychiurus* :**

Gervais (1841) established the genus *Onychiurus* which can be separated, from other genera of the family Onychiuridae, by (1) sense clubs in Ant. org. III smooth or granulated, straight or inclined but never directed towards each other, (2) at least seven segments of the body with more than one pseudocellus, and (3) body-shape with maximum width in region of Abd. III/IV, rarely in region of Th. III/Abd. I. Subsequent to that, many attempts to split up this genus into subgenera have been made by various investigators such as Absolon (1901), Börner (1901a and 1901b) and Bagnall (1947 and 1949). Stach (1954) while suggesting splitting *Onychiurus sens. lat.* into 10 distinct genera, regarded such a division as being impracticable at the moment. In reference to Bagnall (1947 and 1949) Stach remarked that Bagnall had created a new genus for almost every species of Onychiuridae.

Handschin (1920) proposed, for the first time, the system of dividing the genus into "species groups" and created four groups e.g., *affinis*, *sibiricus*, *armatus* and *ramosus* on the basis of the pattern of the postantennal organ (P. A. O.). Gisin (1952a) introduced three more such groups, namely, *fimetarius*, *ambulans* and *handschini* and in recent years described a large number of new species under these abovementioned "species groups". Stach (1954) considered most of Gisin's species as ecological or local modifications because of the inconsistency of the characters employed by Gisin. The present author however, feels that the division of the genus into arbitrary "species groups" is perhaps the most convenient method in Collembolan taxonomy because of the reasons : (i) from the point of view of classification and identification, large unwieldy genera are inconvenient, (ii) the present knowledge of the family Onychiuridae is still too inadequate to group the species into subgenera or genera other than large ones, *Onychiurus* and *Tullbergia*, (iii) some of them especially those proposed by Bagnall (1949) only exhibit insignificant differences and finally (iv) the division into "species groups" does not prejudice the case at an early stage and burden the group with numerous nominal genera and subgenera but may provide convenient "Key" groups.

Further, owing to the inadequacy of the original descriptions of many species of this genus, which fall far short of modern taxonomic requirements, their true systematic picture and affinity with other related forms can not be ascertained as emphasized by Choudhuri (1962). From the above discussion it is perhaps clear that there exists no stability as regards the systematics of this genus.

## Evaluation of the taxonomic criteria in vogue :

In view of the disagreement between the Collembolan systematists it is considered worthwhile to evaluate the characters utilised by previous workers particularly Bagnall and Gisin, since both of them have described a good number of the British species of *Onychiurus*, so as to reject the unreliable ones and to arrive at a set of criteria which can be used with individuals of all ages. The high frequency of variation of some of Bagnall's characters *viz.*, body-colour, number of vesicles in the P. A. O. and relative lengths of the different parts of the body has already been pointed out by the present author (1963c). Besides, Bagnall's descriptions are too short to make any real taxonomic assessment. Similarly some of Gisin's characters are highly variable even in different instars of the same individual as mentioned later. The chief characters used by Gisin are as follows :

(a) *Relative lengths of the body as a whole or any part of it.*—This varies greatly amongst the members of the same population ; between populations drawn from different habitats (Table 1) ; amongst the insects reared at different temperatures (Choudhuri, 1963b) and amongst the various juvenile forms of the same species (Appendix I).

TABLE 1

*Total growth of body and lengths of setae 'M', 'S' on Abd. V and anal spines of populations of various localities (measured in mm.)*

Species	Locality of Collection	Maximum body length	Length of seta		Length of anal spine
			'M'	'S'	
<i>O. armatus</i>	Kensington gardens, London	0.22	0.36	0.17	0.17
	Groombridge, Sussex, U.K.	0.23	0.26	0.13	0.21
<i>O. campatus</i>	Gwedyr forest, Wales, U.K.	0.29	0.29	0.29	0.28
	Essex, U.K.	0.24	0.43	0.33	0.21
	Surrey, U.K.	0.28	0.43	0.32	0.20
	Devonshire, U.K.	0.25	0.38	0.24	0.26
	Westmorland, U.K.	0.28	0.37	0.28	0.27
	Berkshire, U.K.	0.25	0.29	0.14	0.28
<i>O. waterstoni</i>	Westmorland, U.K.	0.28	0.29	0.15	0.14
	Berkshire, U.K.	0.24	0.43	0.19	0.17
	Gwedyr forest, Wales, U.K.	0.20	0.41	0.15	0.13
	Geneva	0.21	0.39	0.16	0.16
<i>O. fimatus</i>	Berkshire, U.K.	0.27	0.35	0.17	0.29
	Essex, U.K.	0.26	0.36	0.16	0.18

(b) *Number and arrangement of pseudocelli.*—Much reliance has been placed on it by Gisin. The present author finds that although the number of pseudocelli

varies considerably in certain parts of the body, their basic pattern remains more or less unchanged. Of special interests is the association of the variation in number with the rise of temperature as already reported by Hammer (1953). The analysis of the variation in pseudocelli (Tables 2 and 3) shows that in the "armatus group" the number of pseudocelli on all parts of the body except the hind margin of head and the 5th abdominal tergite rarely shows more than 10% variation (highest permissible level) while in the "fimetarius group" the segments excepting the tergites of abdomen IV-V, sternites of abdomen III and to some extent the subcoxae, similarly never exceed a level of 10% variation. Therefore, only the segments having a fairly constant number of pseudocelli are of systematic importance and not the pseudocelli over the whole body.

TABLE 2  
% Variation of pseudocelli in "armatus group"

Species	Antennal base	Posterodorsal head	Tergites of Abdomen					Head Ventral
			I	II	III	IV	V	
1	3.0	15.0	3.0	0	0	1.0	13.0	0
2	0	3.0	6.0	0	0	3.0	6.0	0
3	0	3.0	1.4	0	0	4.0	7.0	0
5	4.0	16.0	0	0	0	8.0	12.0	0
6	0	2.5	0	0	0	16.0	5.0	0
7	0	2.5	2.6	0	1.3	0	0	0
8	4.0	42.0	0	0	0	4.0	8.0	0
10	0	7.0	0	7.0	0	14.0	7.0	0
11	0	25.0	0	0	0	0	12.5	0
12	0	3.0	3.0	0	0	3.0	3.0	0
15	0	0	0	0	0	0	0	0
16	0	7.5	0	0	0	0	2.5	0

TABLE 3a  
% Variation of dorsal pseudocelli in "fimetarius group"

Species	Antennal base	Posterodorsal head	Thorax	Abdomen	Abdomen
			I	IV	V
<i>O. imperfectus</i>	0	0	60.0	8.0	0
<i>O. gotoi</i>	0	0	0	0	0
<i>O. stachianus</i>	0	0	10.0	25.0	42.5

TABLE 3b  
% Variation of ventral pseudocelli in "fimetarius group"

Species	Head	Thorax II	Thorax III	Abdomen I	Abdomen III	Subcoxa I
<i>O. imperfectus</i>	0	0	2.0	2	0	2.0
<i>O. gotoi</i>	0	6.7	3.3	10.0	20.0	3.3
<i>O. stachianus</i>	2.5	2.5	2.5	2.5	2.5	7.5

(c) *Chaetotaxy*.—The use of the setae and scales of Collembola dates back to the last century. Börner (1901) and Schött (1927) both considered them of great value for devising the basic classificatory divisions. More recently Cassagnau, Yoshii and Gisin have used chaetotaxy as a systematic character of great importance. Gisin (1952) developed a system based on chaetotaxy for the separation of closely related species, especially in "armatus" and "fimetarius" groups.

(a) *Tergite of Th. I*.—Gisin's (1952) formula "i3m" to express the chaetotaxy of the different species of the "armatus group" works only in the adults as the number of setae varies from instar to instar. Infact, Gisin himself (in litt.) stated, "as far i on Th. I, it often lacks on immature individuals" The author has noticed the seta "i" appears in the fourth instar and also that all of Gisin's chaetotactic formulae in relation to this segment are found to occur in the different instars of the same individual. Even in case of adults "i3" of the posterior half is seen to be reasonably constant but "m" appears to be extremely variable being absent occasionally either from one or both sides as in *O. fimatus*, *O. aurantiacus*, *O. campatus* and others, and also in appearing abnormally in *O. waterstoni* and probably others. On the other hand there are many species such as, *O. armatus*, *O. subarmatus*, *O. nemoratus*, *O. tricampatus*, *O. pseudovanderdrifti* and others where "m" is constantly absent. Evidently the taxonomic value of "m" is limited. Hence Gisin's formula instead of being used as it is, should be modified as follows : (1) "i3" should be used in the separation of the instars, and (2) "m" should have systematic consideration only where it does not show more than about 10% variation.

(b) *Abdomen II and V*. Gisin (1952) lettered certain setae in the vicinity of the dorsomedian pseudocelli (M, M<sup>1</sup>, S and S<sup>1</sup>) and classified various species of the "armatus group" on the basis of their number. After having examined numerous specimens of the different species, the present writer has no doubt that this character can be used throughout the "armatus group" except in a few species, such as, *O. pulvinatus* and *O. tricampatus* where frequent aberrations occur. With regard to *O. pulvinatus* Gisin (in litt.) admitting the highly variable nature of this character remarked, "a little correction to be made on my first description of this species. The holotype has no seta "S<sup>1</sup>" on Abd. V, but I verified on the paratype material that such a seta occurs frequently with this species." In species like *O. campatus* and *O. bicampatus* although occasionally only one seta "S" is found (in place of both "S" and "S<sup>1</sup>") either on one or both sides, such variation has never been observed on all the segments of a specimen, especially in mature individuals. Thus, this character does seem to be a valuable one.

Since 1952, Gisin has been using throughout the "armatus group" the ratio of the lengths of M/S on the tergites of Abd. V and anal spines. Some of his newly

created species as gathered from his description, differ from one another only in this character. No one has so far challenged the validity of this character. However, in the Table 1 it has clearly been shown that this ratio varies considerably amongst the specimens belonging to the same species but collected from different localities. Moreover, the unreliability of this character becomes more pronounced when the average measurements of the juveniles are compared side by side with those of the adults (Appendix I). It will be noticed that these two measurements do not even approach each other and eventually the separation of species on the basis of such a character stands unreliable.

(c) *Abdomen VI*.—The arrangement of the dorsal setae in association with the anal spines has proved to be very constant. Unfortunately the usefulness of this criterion has been marred by the application of some deceptive terms, "sub-parallel" and "little convergent". The distinction between these two terms is hardly perceptible in Gisin's work as they are neither defined nor illustrated. The present author suggests that chaetotaxy of this segment should be classified into 3 types; (1) "Near Convergent" to include all the forms where the microsetae "q" and "r" in front of the anal spines of each side converge decidedly before the posterior margin of the preceding segment (Fig. 3); (2) "Remote Convergent" representing those where the corresponding microsetae converge behind the posterior margin of the preceding segment (Fig. 4) and lastly (3) "Parallel" to include forms where corresponding microsetae form two almost parallel lines (Fig. 2).

(d) *Ventral tube*.—Gisin (1952) considered the basal setae of the ventral tube as one of the diagnostic characters of the "*armatus* group". In the present work it is shown that the basal setae vary from instar to instar within a certain age limit. For instance, one of the two setae in both *O. fimatus* and *O. parthenogeneticus* appears for the first time in the 4th instar.

(e) *Teeth on the unguis*.—Throughout this study it has been found that this character has no value as a taxonomic character, owing to its wide variation, even between the unguis of the same specimen. Moreover, it first appears at an advanced stage in postembryonic development, for instance in *O. fimatus* it appears first at the 6th instar. Above all, it is seen to develop occasionally in those species where it is normally absent in all instars.

However, the basal setae in conjunction with the anterior and distal setae of the ventral tube have proved to be valuable for separating "groups" and also for the determination of instars.

Of the other characters used by various systematists, the sense organ on the third antennal segment, the basal lamella on the unguiculus, the blunt setae on the surface of the body and to some extent the ventral organ seem to be reasonably reliable in their proper perspective.

#### Search for new characters :

*For individuals of various ages*.—The tables 4 and 5 show the percentage variations of some characters of the individuals of various ages in *O. fimatus* and *O. imperfectus*. It will be noted that in *O. fimatus* the number of setae on the ventral surface of the first antennal segment from the V instar to the adult; the anterior half of the tergite of Th. I. from the III instar to the adult; the inner two rows of the dorsomedian part of Abd. II and IV from the III instar to the adult; lateral part of the tergite of Abd. V in case of the VI instar and adult; and the teeth in

the unguis display more than 10% variation. In *O. imperfectus* the number of setae on the anterior half of the tergite of Th. I. ; two inner rows of the tergite of Abd. II and tergite of Abd. IV varies a good deal.

Leaving aside these variable characters all others have been used in the diagnosis of the various instars of *O. fimatus* (Tables 6a and 6b) and *O. imperfectus* (Tables 7a and 7b). The meaning of the symbols used in place of characters are given in the Appendix II.

TABLE 4

% Variation of some characters of individuals of various ages in *O. fimatus*

Characters (Appendix II)		Instars						Adult
		I	II	III	IV	V	VI	
Chaetotaxy	<i>a</i>	0	0	10.0	8.0	12.0	17.0	17.0
	<i>b</i>	0	0	0	0	4.0	5.0	5.0
	<i>c</i>	0	0	1.0	2.0	2.0	7.0	6.0
	<i>d</i> (3)	0	0	—	30.0	—	—	—
	<i>d</i> (2)	0	0	1.0	5.0	4.0	8.0	9.0
	<i>e</i>	0	0	8.0	5.0	3.0	5.0	10.0
	<i>f</i> (3)	0	0	40.0	26.0	20.0	20.0	22.0
	<i>g</i> (2)	0	0	—	16.0	26.0	30.0	—
	<i>h</i> (1)	0	0	10.0	10.0	10.0	7.5	10.0
	<i>h</i> (3)	0	0	0	3.0	10.0	16.0	26.0
	<i>i</i>	0	0	0	0	0	0	0
	<i>j</i> (1)	0	0	0	0	0	3.0	5.0
	<i>j</i> (4)	4.0	2.0	5.0	3.0	3.0	0	2.5
	<i>j</i> (3)	0	0	8.0	3.0	8.0	4.0	6.0
	<i>k</i> (1)	0	0	0	38.0	6.0	4.0	10.0
	<i>k</i> (2)	0	0	0	0	0	0	0
	<i>l</i> (1)	0	0	0	0	6.0	24.0	13.0
	<i>l</i> (4)	0	0	0	0	0	0	0

For adults of twenty-six species.—Of twenty-six species, twenty belong to "armatus group" which are characterised as having (1) P. A. O. with simple vesicles almost at right angles to long axis of organ, (2) furca absent or reduced, (3) Ant. Org. III with botryoidal and usually granulated sense clubs, (4) usually without ventral organ in male and (5) presence of anal spines. The rest six species fall under "fimetarius group". The latter is diagnosed by (1) multilobed vesicles in the P. A. O., (2) absence of anal spines, (3) reduced tergite of Abd. VI with a seta named as "a" (Fig. 20), (4) without furca and (5) presence or absence of ventral organ in male. The percentage variations of some characters which are usually

employed in any systematical study of Collembola are recorded for "armatus group" in the table 8 and for "fimetarius group" in the table 9. Table 8 indicates that the ventral surface of the I antennal segment in *O. fimatus*, *O. armatus*, *O. campatus*, *O. humatus*, *O. subarmatus*, *O. fimatus*, *O. waterstoni*, *O. tricampatus* and *O. subuliginatus*; the tergite of Th. I in both the anterior and posterior half; the setae "S" on the tergite of the Abd. V in *O. pulvinatus*; the outer semicircular margin of the upper anal valve in *O. pulvinatus*, *O. waterstoni*, *O. subarmatus*, and *O. subuliginatus*; and the tooth in the unguis of *O. armatus*, *O. campatus*, *O. pulvinatus*, *O. waterstoni*, *O. prolatus*, *O. subarmatus*, *O. tricampatus*, *O. fimatus* and *O. parthenogeneticus*, show more than 10% variation. Of these variable characters the chaetotaxy of the outer semicircular margin of the upper anal valve appears to be relatively more useful and as such this should not be ignored. In the table 10 the diagnostic characters of the nineteen species of "armatus group" are laid down. Table 9 shows that except for the tergite of Th. I., distal outer row of the ventral tube and lateral tooth in unguis all other characters vary within the limits of 10% and therefore are useful for systematic purpose. For the sake of convenience in identifications, the diagnostic characters of four species of "fimetarius group" are given in the Table 11. The meaning of the different symbols used in the tables 10 and 11 are given in the Appendices III and IV.

TABLE 5

% Variation of some characters of individuals of various ages of *O. imperfectus*

Characters (Appendix II)		Instars						
		I	II	III	IV	V	VI	Adult
Chaetotaxy	<i>a</i>	0	0	0	0	0	0	0
	<i>b</i>	0	0	0	0	0	0	0
	<i>c</i>	0	0	0	0	8.0	10.0	10.0
	<i>d</i> (3)	0	0	22.0	22.0	10.0	28.0	40.0
	<i>d</i> (2)	0	0	0	0	0	8.0	12.0
	<i>e</i>	0	0	6.0	2.0	6.0	8.0	10.0
	<i>f</i> (3)	0	0	20.0	16.0	20.0	16.0	24.0
	<i>g</i> (2)	0	0	4.0	20.0	28.0	32.0	24.0
	<i>h</i> (1)	0	0	0	0	4.0	6.0	4.0
	<i>h</i> (3)	0	2.5	—	—	—	—	—
	<i>i</i>	0	0	0	0	0	0	0
	<i>j</i> (1)	0	0	0	0	0	0	0
	<i>j</i> (4)	0	0	0	0	0	0	0
	<i>j</i> (3)	0	0	4.0	4.0	6.0	8.0	6.0
	<i>k</i> (1)	0	0	8.0	0	0	4.0	0
	<i>k</i> (2)	0	0	0	0	0	0	0
	<i>k</i> (3)	0	0	0	0	0	0	0
	<i>l</i> (2)	0	0	0	0	28.0	36.0	36.0
	<i>l</i> (4)	5.0	0	0	0	0	0	0

TABLE 6a

*Diagnostic chaetotactic characters of individuals of various ages in O. fimatus*

Characters (Appendix II)	I	II	III	Instars IV	V	VI	Adult
<i>a</i>	2	3	4	5	5 or 6	5 or 6	5 or 6
<i>b</i>	3 (0) 3	10 (1) 10	10 (1) 10	10 (1) 10	10 (1) 10	10 (1) 10	10 (1) 10
<i>c</i>	2	3	4	4	4	4	4
<i>d</i> (3)	0	1	2-4	—	—	—	—
<i>d</i> (2)	1	4	4	5	6	7	7
<i>e</i>	1	2	3	5	5	5	5
<i>f</i> (1)	0	1+1	2+2	2+2	2+2	2+2	2+2
<i>f</i> (3)	2+2	2+2	—	—	—	—	—
<i>g</i> (1)	1+1	2+2	2+2	2+2	2+2	2+2	2+2
<i>g</i> (3)	1+1	2+2	—	—	—	—	—
<i>h</i> (1)	2+0	4+2	4+7	4+7	4+7	4+7	4+7
<i>h</i> (3)	2+0	3+1	3+1	4+1	5+1	?+1*	?+1*
<i>i</i>	2 (0) 2	2 (1) 2	3 (1) 3	3 (1) 3	3 (1) 3	3 (1) 3	3 (1) 3
<i>j</i>	0+5	1+5	1+6	2+7	2+8	2+9	2+10
<i>k</i> (1)	1 (1) 1	2 (1) 2	2 (1) 2	2 (1) 2-3 (1) 3	3 (1) 3	3 (1) 3	3 (1) 3

TABLE 6b

*Characters other than chaetotaxy of individuals of various ages in O. fimatus*

Instars	Pseudocelli	Inner tooth in unguis	Genital aperture
I	$\frac{32/022/33332}{1/000/00000}$	Absent	Absent
II	$\frac{32-3/022/33332-3}{1/000/00000}$	Absent	Absent
III	$\frac{33/022/33333*}{1/000/00000}$	Absent	Present
IV	"	Absent	Present
V	"	Absent	Present
VI	"	Present or Absent	Present
Adult	"	Present or absent	Present

\*Variable.

TABLE 7a  
*Diagnostic chaetotactic characters of individuals of various ages in O. imperfectus*

Characters Appendix II)	Instars						
	I	II	III	IV	V	VI	Adult
<i>a</i>	2	3	3	3	3	3	3
<i>b</i>	2 (1) 2	8 (1) 8	9 (1) 9	9 (1) 9	9 (1) 9	9 (1) 9	9 (1) 9
<i>c</i>	2	3	3	3	4	4	4
<i>d</i> (3)	0	0	2-3	—	—	—	—
<i>d</i> (2)	1	4	4	6	6	6	7
<i>e</i>	1	2	3	4	5	5	5
<i>f</i> (1)	0	1+1	2+2	3+3	3+3	3+3	3+3
<i>f</i> (3)	2+2	2+2	—	—	—	—	—
<i>g</i> (2)	3 (0) 3	4 (1) 4	6 (1) 6	7 (1) 7	7 (1) 7	7 (1) 7	7 (1) 7
				or more	or more	or more	or more
<i>h</i> (1)	2+2	3+3	3+3	3+3	3+3	3+3	3+3
<i>i</i>	4+4	5+4	5+4	5+4	5+4	5+4	5+4
<i>k</i> (1)	1 (1) 1	1 (1) 1	2 (1) 2	2 (1) 2	2 (1) 2	2 (1) 2	2 (1) 2
<i>j</i>	0+0+4+0	0+0+4+0	0+0+4+1	0+0+4+2	0+0+4+2	0+0+4+3	0+0+4+3

TABLE 7b  
*Characters other than chaetotaxy of individuals of various ages in O. imperfectus*

Instars	Pseudocelli	Lateral tooth in Unguis	Genital aperture
I	$\frac{32/133/33333}{3/000/2212}$	Absent	Absent
II	$\frac{32/133/3333-53-4}{3/00-1\ 0-1/2212}$	Absent	Absent
III	$\frac{33/133/33354^*}{3/011/2212}$	Absent	Present
IV	„	Absent	Present
V	„	Present or Absent	Present
VI	„	Present or Absent	Present
Adult	„	Present or Absent	Present

\*Variable.

TABLE 8  
% Variation of some characters in "armatus group"

Species	Chaetotactic characters (Appendix II)															Other characters	
	a	b	c	d(1)	e	f(1)	f(2)	g(1)	h(1)	h(2)	i	j(1)	j	j(4)	k(2)	l(1)	l(2)
1	18	4	4	39	17	8	0	0	0	10	4	0	4	2	0	34	-
2	41	0	0	0	30	3	0	0	3	6	3	0	0	-	9	12	-
3	23	0	3	19	27	4	6	9	7	9	10	0	1.5	-	0	26	-
5	8	0	0	15	50	8	0	8	4	0	54	0	0	-	23	40	-
6	10	5	0	24	47	8	4	0	0	10	0	0	5	-	0	0	-
7	21	3	5	20	14	3	3	0	8	5	0	0	4	-	40	20	-
8	31	0	0	19	12	0	0	0	4	0	8	0	8	-	0	0	-
10	0	0	0	0	75	6	6	0	0	6	0	0	0	-	0	25	-
11	0	0	0	13	0	0	0	12	0	0	0	0	0	-	0	0	-
12	28	0	0	0	25	3	3	0	8	6	0	0	6	-	28	17	-
15	20	0	0	5	25	0	5	0	0	0	0	0	0	-	20	0	-
16	15	5	0	5	20	2	2	10	10	10	-	0	8	-	0	15	-
19	5	0	0	4	0	4	0	0	0	10	0	0	0	1	0	0	17
20	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	-
23	7	0	0	14	7	0	0	0	0	0	0	0	0	-	0	0	-

TABLE 9  
% Variation of some characters in "fimetarius group"

Characters (Appendix II)	<i>O. imperfectus</i> Denis	<i>O. gotoi</i> Choudhuri, 1958	<i>O. stachianus</i> Bagnall
a	0	0	0
b	0	0	0
c	10	0	0
d (2)	12	10	25
e	10	10	7
f (1)	2	0	0
h (1)	4	3	0
i	0	0	0
j (3)	6	13	18
j (4)	0	0	0
k (1)	0	0	2
k (2)	0	0	0
l (1)	—	7	—
l (2)	36	—	30

TABLE 10  
Diagnostic characters (chaetotactic) for "armatus group"

Species	Chaetotactic characters (Appendix II)										
	<i>a</i>	<i>b</i>	<i>c</i>	<i>e</i>	<i>f</i> (1)	<i>g</i> (2)	<i>h</i> (1)	<i>h</i> (2)	<i>i</i>	<i>j</i>	<i>k</i> (2)
1	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>
2	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i> or <i>b</i>
3	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>c</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>b</i>
5	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>	<i>a</i> or <i>b</i>	<i>a</i>	<i>a</i>	<i>a</i> or <i>b</i>
6	<i>a</i>	<i>c</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>c</i>	<i>a</i>	<i>a</i>
7	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>c</i>	<i>a</i>	<i>c</i>	<i>a</i>	<i>a</i> or <i>b</i>
8	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>
10	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>c</i>	<i>a</i>	<i>a</i>
11	<i>a</i>	<i>d</i>	<i>a</i>	<i>c</i>	<i>c</i>	<i>b</i>	<i>b</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>b</i>
12	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i> or <i>b</i>
15	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>c</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i> or <i>b</i>
16	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>c</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>
17	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>
18	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>a</i>	?
19	<i>b</i>	<i>e</i>	<i>c</i>	<i>d</i>	<i>b</i>	<i>a</i>	<i>d</i>	<i>a</i>	<i>e</i>	<i>b</i>	<i>a</i>
20	<i>b</i>	<i>e</i>	<i>c</i>	<i>d</i>	<i>b</i>	<i>a</i>	<i>e</i>	<i>a</i>	<i>e</i>	<i>b</i>	<i>a</i>
21	<i>b</i>	<i>e</i>	<i>c</i>	<i>d</i>	<i>b</i>	<i>a</i>	<i>e</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>b</i>
23	<i>a</i>	<i>f</i>	<i>d</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>d</i>	<i>a</i>	<i>a</i>
24	<i>b</i>	<i>a</i>	<i>e</i>	<i>d</i>	<i>b</i>	<i>a</i>	<i>e</i>	<i>a</i>	<i>a</i>	<i>b</i>	<i>c</i>
Column	1	2	3	4	5	6	7	8	9	10	11

TABLE 11  
Diagnostic chaetotactic characters for "fimetarius group"

Characters (Appendix II)	<i>O. imperfectus</i>	<i>O. stachianus</i>	<i>O. gotoi</i>	<i>O. pygmaeus</i>	Column
<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	1
<i>b</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	2
<i>c</i>	<i>a</i>	<i>b</i>	<i>b</i>	<i>a</i>	3
<i>e</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>	4
<i>f</i> (1)	<i>a</i>	<i>a</i>	<i>a</i>	<i>a</i>	5
<i>g</i> (2)	<i>a</i>	<i>a</i>	<i>a</i>	<i>b</i>	6
<i>i</i>	<i>a</i>	<i>d</i>	<i>b</i>	<i>d</i>	7
<i>j</i> (1)	No seta	No seta	No seta	1 seta	8
<i>j</i> (2)	"	"	"	"	9
<i>k</i> (1)	<i>a</i>	<i>a</i>	<i>a</i>	--	10
<i>l</i>	<i>a</i>	<i>b</i>	<i>d</i>	<i>b</i>	11

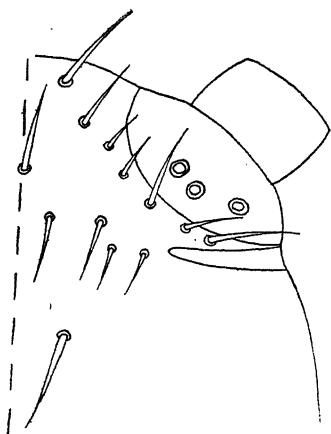


Fig. 1. Chaetotaxy of anterodorsal part of head in *O. bicampatus*.

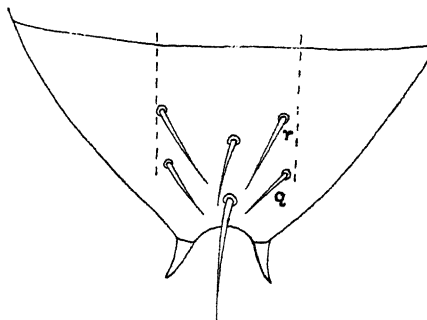


Fig. 2. "Parallel" chaetotaxy of Abd. VI.

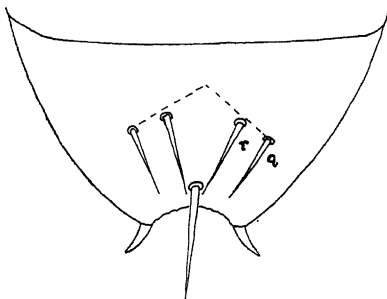


Fig. 3. "Near convergent" chaetotaxy of Abd. VI.

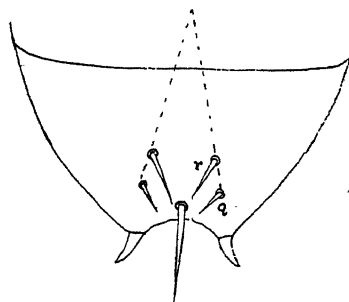


Fig. 4. "Remote convergent" chaetotaxy of Abd. VI.

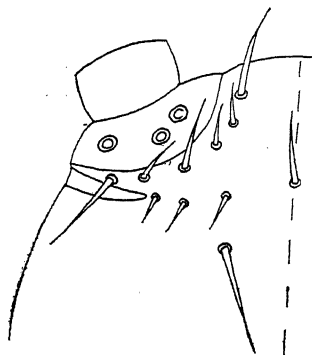


Fig. 5. Chaetotaxy of anterodorsal part of head in *O. campatus*.

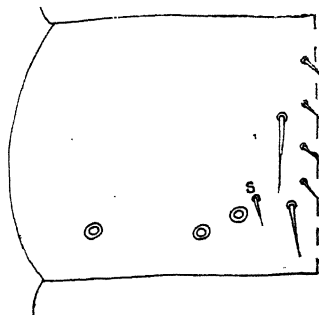


Fig. 6. Chaetotaxy of type *a* on dorsomedian part of Abd. II.

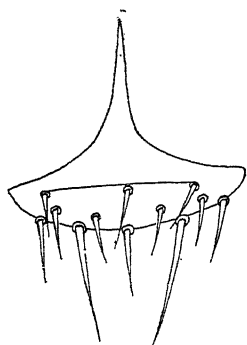


Fig. 7. Chaetotaxy of type *a* on upper anal valve.

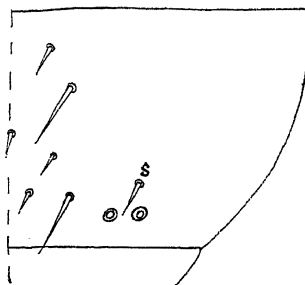


Fig. 8. Chaetotaxy of dorsomedian part of Abd. V in *O. pulvinatus*.

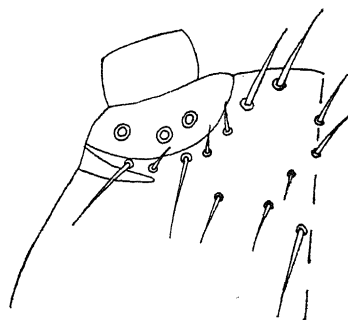


Fig. 10. Chaetotaxy of anterodorsal part of head in *O. humatus*.

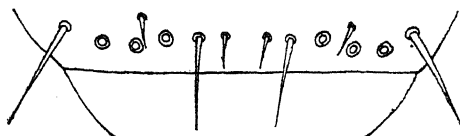


Fig. 9. Chaetotaxy of dorsomedian part of Abd. V in *O. tricampatus*.

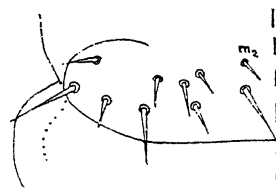


Fig. 11. Chaetotaxy of tergite of Th. I in *O. caledonicus*.

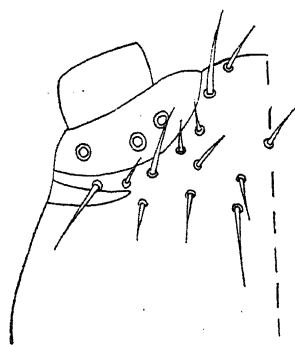


Fig. 12. Chaetotaxy of anterodorsal part of head in *O. aurantiacus*.

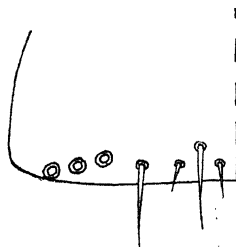


Fig. 13. Chaetotaxy of posterodorsal part of head in *O. aurantiacus*.

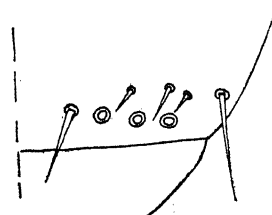


Fig. 14. Chaetotaxy of dorsomedian part of Abd. V in *O. prolatus*.



Fig. 15. Acuminate unguiculus with basal inner lamella.

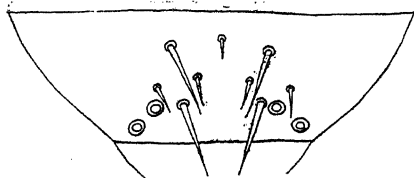


Fig. 16. Chaetotaxy of dorsomedian part of Abd. V in *O. parthenogeneticus*.

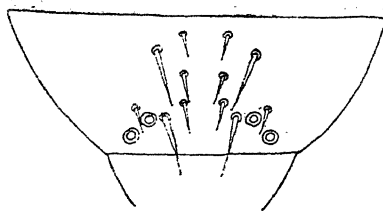


Fig. 17. Chaetotaxy of dorsomedian part of Abd. V in *O. hortensis*.



Fig. 18. Ant. org. III of "fimetarius group".

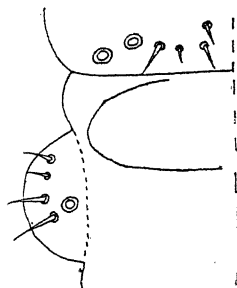


Fig. 19. Chaetotaxy of subcoxa I in *O. stachianus*.

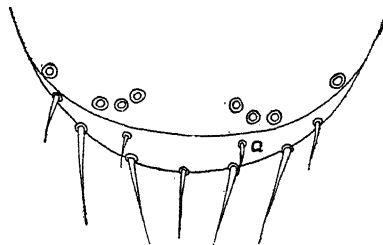


Fig. 20. Chaetotaxy of tergite of Abd. VI in *O. imperfectus*.

The name of the species numbered in the tables throughout this paper is as follows: 1. *O. fimatus* Gisin, 2. *O. armatus* (Tullb.) Gisin, 3. *O. campatus* Gisin, 5. *O. pulvinatus* Gisin, 6. *O. aurantiacus* (Ridley) Choudhuri, 7. *O. waterstoni* Bagnall, 8. *O. humatus* Gisin, 10. *O. prolatus* Gisin, 11. *O. bicampatus* Gisin, 12. *O. subarmatus* Gisin, 15. *O. subuliginatus* Gisin, 16. *O. ricampatus* Gisin, 17. *O. caledonicus* Bagnall, 18. *O. daviesi* Bagnall, 19. *O. parthenogeneticus* Choudhuri, 20. *O. hortensis* Gisin, 21. *O. moniezi* Bagnall, 23. *O. furciferus* (Börner), and 24. *O. halophilus* Bagnall (all of "armatus" group).

The new chaetotactic characters introduced here are: the chaetotaxy of the anterodorsal part of head, of the posterodorsal part of head between the pseudocelli, of the subcoxa of the Leg I, of the outer two rows of the dorsomedian part of Abd. II and V, of the tergite of Abd. VI, of the ventral tube (anterior, basal and inner distal row), of the posteromedian part of the sternite of Abd. II and of the upper anal valve. Characters of more or less limited application are: (1) the setae on the outer two rows of the dorsomedian part of Abd. IV and (2) the posteromedian part of the sternite of Abd. II. The greater usefulness of these characters lies in their universal application from the imago upto the third instar. The recognition of these characters has made it possible to frame a new key as presented here.

Mention must be made that the present observations have enabled the author to form definite opinions as to the position of some controversial species namely *O. uliginatus* Gisin, *O. sublatus* Gisin, *O. flavidulus* Bagnall, *O. s-vontornei* Gisin, *O. latus* Gisin, *O. procampatus* Gisin, *O. evansi* Bagnall, and *O. pseudostachianus* Gisin. *O. s-von-*

*tornei* and *O. procampatus* are synonyms of *O. humatus* Gisin and *O. campatus* Gisin respectively. The synonymy of rest of the species has already been discussed by the author (1962 and 1963c). The controversy between *O. burmeisteri* (Lubbock) and *O. terberculatus* (Moniez) has been settled by the author (1963a).

Key to the twenty seven British species of "armatus" and "fimetarius" groups.

1. Pseudocelli on tergites with distinct cuticular inner rim..... 2.
- 1a. Pseudocelli on tergites without cuticular inner rim, two round cuticular patches in front of the genital aperture (Choudhuri, 1963a). Cuticular granulation remarkably coarse, usually no pseudocelli on the ventral surface, P. A. O. with simple vesicles, Abd. VI tergite with parallel setae; blunt setae all over the body, linea dorsalis distinct.

1. *O. burmeisteri* (Lubbock, 1873).

2. P. A. O. with simple vesicles.....3.
- 2a. P. A. O. with compound vesicles. ....22.
3. Furca present.....4.
- 3a. Furca absent.....18.
4. Furca vestigial (at most in an integumentary fold).....5.
- 4a. Furca better developed (*vide* Fig. 11; Choudhuri, 1963c), Furca with 3-4 simple or forked setae on each side, cuticular granulation fine, 2+2 pseudocelli on tergite of Th. II and 3+3 pseudocelli on tergite of Abd. V. Abdomen VI with characteristic parallel setae (*vide* Fig. 14; Choudhuri, 1963c), unguis with an inner tooth and unguiculus without basal lamella, anal spines strong and curved.

2. *O. furciferus* (Börner, 1901)

5. Subcoxa I with pseudocellus .....6.
- 5a. Subcoxa I without pseudocellus; 4+4 pseudocelli on tergite of Abd. IV and 2+2 pseudocelli on tergite of Th. II. Abd. VI with chaetotaxy of type *a* and anterodorsal part with typical chaetotaxy type *d* (Fig. 1).

3. *O. bicampatus* Gisin, 1956.

6. Tergite of Abd. VI with chaetotaxy of either type *a* or *b*.....7.
- 6a. Tergite of Abd. VI with chaetotaxy of type *c* (Fig. 2).....16.
7. Tergite of Abd. VI with chaetotaxy of type *a* (Fig. 3).....8.
- 7a. Tergite of Abd. VI with chaetotaxy of type *b* (Fig. 4).....14.
8. Dorsomedian part of Abd. II with both setae S and S<sup>1</sup> close to median pseudocelli, 3+3 pseudocelli on tergite of Abd. V and 4+4 pseudocelli on tergite of Abd. IV; anterodorsal head with chaetotaxy of type *a* (Fig. 5).

4. *O. campatus* Gisin, 1956.

- 8a. Dorsomedian part of Abd. II with only one seta S close to median pseudocelli.....9.
9. Dorsomedian part of Abd. II with chaetotaxy of type *b*.....10.

- 9a. Dorsomedian part of Abd. II with chaetotaxy of type *a* (Fig. 6). Tergite of Abd. IV with 3+3 pseudocelli, anterodorsal part of head with chaetotaxy of type *a*, posterodorsal part of head with chaetotaxy of type *a* and upper anal valve with chaetotaxy of type *a* (Fig. 7).
5. *O. fimatus* Gisin, 1952
- 10 Middle part of Abd. V with chaetotaxy of type *b* or *c*.....11.
- 10a. Middle part of Abd. V with chaetotaxy of type *a*.....12.
11. Middle part of Abd. V with chaetotaxy of type *b* (Fig. 8), posterodorsal part of head with chaetotaxy of type *a*, tergite of Abd. V with one S or both S and S<sup>1</sup> close to median pseudocelli; 2+2 pseudocelli on tergite of Th. III and Abd. V.
6. *O. pulvinatus* Gisin, 1954.
- 11a. Middle part of Abd. V with chaetotaxy of type *c* (Fig. 9), 3+3 pseudocelli on tergite of Th. III and Abd. V.
7. *O. tricampatus* Gisin, 1956.
12. Anterodorsal part of head with chaetotaxy of type *a*.....13.
- 12a. Anterodorsal part of head with chaetotaxy of type *b* (Fig. 10), 5+5 pseudocelli on tergite of Abd. IV. unguis without inner tooth.
8. *O. humatus* Gisin, 1952.
13. Antennal base and tergite of Abd. IV with 3 and 4 pseudocelli respectively on each side, anterior half of tergite of Th. I without seta *m*<sub>2</sub> (Fig. 11), 3+3 pseudocelli on the tergite of Th. III.
9. *O. armatus* (Tullberg) Gisin, 1952.
- 13a. Antennal base and tergite of Abd. IV with 4 and 5 pseudocelli respectively on each side, anterior half of tergite of Th. I with seta *m*<sub>2</sub> (Fig. 11).
10. *O. caledonicus* Bagnall, 1935
14. Middle part of Abd. V with chaetotaxy of type *a* .....15.
- 14a. Middle part of Abd. V with chaetotaxy of type *c*; tergite of Th. III with 3+3 and tergite of Abd. IV with 4+4 pseudocelli; anterior half of tergite of Th. I without seta *m*<sub>2</sub>, anterodorsal head with chaetotaxy of type *a*.
11. *O. subuliginatus* Gisin, 1956.
15. Antennal base and tergite of Abd. IV with 3 and 4 pseudocelli respectively on each side; anterior half of tergite of Th. I with seta *m*<sub>2</sub>.
12. *O. subarmatus* Gisin, 1956.
- 15a. Antennal base and tergite of Abd. IV with 4 and 5 pseudocelli respectively on each side; anterior half of tergite of Th. I with seta *m*<sub>2</sub>.
13. *O. daviesi* Bagnall, 1935.
16. Anterodorsal part of head with chaetotaxy of type *a* (Fig. 5).

16a. Anterodorsal part of head with chaetotaxy of type *c* (Fig. 12); postero-dorsal part of head with chaetotaxy of type *b* (Fig. 13); upper anal valve with chaetotaxy of type *a*, both Th. II and III with 2+2 pseudocelli.

14. *O. aurantiacus* (Ridley, 1880) Choudhuri, 1962.

17. Middle part of Abd. V with chaetotaxy of type *c* and dorsomedian part of Add II with chaetotaxy of type *b*.

15. *O. waterstoni* Bagnall, 1937.

17a. Middle part of Abd. V with chaetotaxy of type *a* (Fig. 14) and dorsomedian part of Abd. II with chaetotaxy of type *a*.

16. *O. prolatus* Gisin, 1956

18. Ant. org. III without accessory sense clubs .....19.

18a. Ant. org. III with a pair of accessory domeshaped sense clubs in addition to usual sense clubs (*vide* Fig. 7; Choudhuri, 1963*b*) unguiculus with granulated basal inner lamella, one pseudocellus on each side of tergite of Th. I and no pseudocelli on thoracic as well as abdominal sternites.

17 *O. moniezi* Bagnall, 1935

19. Unguiculus acuminate and with basal inner lamella (Fig. 15).....20.

19a. Unguiculus with gradually narrowing to apex and without basal inner lamella.....21.

20. Posterodorsal head with 4+4 pseudocelli arranged in a quadrangle, both antennal base and tergite of Abd. I with 4+4 pseudocelli, Abd. sternites I-IV with pseudocelli.

18. *O. halophilus* Bagnall, 1937

20a. Posterodeorsal head with 2+2 pseudocelli arranged in an oblique line, both antennal base and tergite of Abd. I with 3+3 pseudocelli, Abd. sternites I-IV without pseudocelli.

19. *O. debilis* (Moniez) Denis, 1923

21. Ant. org. III with canaliculated and finely granulated sense clubs; antennal base unlimited by granulation, middle part of tergite of Abd. V with chaetotaxy of type *d* (Fig. 16).

20. *O. parthenogeneticus* Choudhuri, 1958

21a. Ant. org. III with uncanaliculated, smooth sense clubs; antennal base delimited by granulation, middle part of tergite of Abd. V with chaetotaxy of type *e* (Fig. 17).

21. *O. hortensis* Gisin, 1949.

22. Ant. org. III with straight and ovoid sense clubs.....23.

22a. Ant. org. III with bean-shaped, canaliculated and inclined sense clubs (Fig. 18).....24.

23. Unguis with inner tooth and subcoxa I with chaetotaxy of type *a* (Choudhuri, 1958) ; ventral organ in male with 4 setae only on Abd. III sternite. Usually no pseudocelli on thoracic II and III sternites and 1+1 pseudocellus on Abd. I sternite and tergite of Abd. VI with chaetotaxy of type *b* (*vide* Fig. 17 ; Choudhuri, 1958).
22. *O. gotoi* Choudhuri, 1958.
- 23a. Unguis with inner tooth, subcoxa I with chaetotaxy of type *b* (Fig. 19), ventral organ in male having 4 setae on both Abd. II and III sternites, 1+1 pseudocellus on thoracic II and III sternites and 2+2 pseudocelli on Abd. I sternite and tergite of Abd. VI with chaetotaxy of type *d* (*vide* Fig. 16, Choudhuri, 1963c).
23. *O. stachianus* Bagnall, 1939.
24. Ventral tube without basal or anterior seta.....25.
- 24a. Ventral tube with one basal and one anterior seta. Posterodorsal head with chaetotaxy of type *a* (Fig. 19) ; no ventral organ in male ; unguiculus without basal lamella ; middle part of Abd. V tergite with chaetotaxy of type *b* (*vide* Fig. 19 ; Choudhuri, 1963c). Ventrally head with 2+2 pseudocelli and tergite of Th. I with 1+1 pseudocellus. Upper anal valve with chaetotaxy of type *d* (Choudhuri, 1958).
24. *O. pygmaeus* Bagnall, 1937.
25. 2+2 pseudocelli on Abd. I sternite and ventral organ in male present. 26.
- 25a. 1+1 pseudocellus on Abd. I sternite and ventral organ in male absent ; unguis without inner tooth, unguiculus without basal lamella.
25. *O. fimetarius* (Linne., 1766) Stach, 1934.
26. Ventral organ in both male and female ; head ventrally with 2+2 pseudocelli and both thoracic II and III sternites with 2+2 pseudocelli.
26. *O. scotarius* Gisin, 1954
- 26a. Ventral organ in male only and represented by a large number of slightly modified setae occupying a large area on Abd. III only ; head ventrally with 3+3 pseudocelli, and both Th. II and III sternites with 1+1 pseudocellus ; tergite of Abd. VI with chaetotaxy of type *a* (Fig. 20).
27. *O. imperfectus* (Denis, 1938) Gisin, 1952.

# APPENDIX I

*Relation of setae "M", "S" and anal spine of 20 individuals representing V instar and adults in O. fimatus*

Length of "M"	V Instar		Length of "M"	Adults	
	Length of "S"	Length of anal spine		Length of "S"	Length of anal spine
2.30	1.00	1.75	2.70	1.30	2.00
2.05	0.90	1.80	2.60	1.20	1.85
2.00	0.85	1.70	2.70	1.35	2.05
2.30	1.00	1.68	2.20	1.00	2.30
2.00	0.90	1.65	2.60	1.20	2.15
2.35	0.90	1.75	2.60	1.40	1.95
2.25	0.90	1.75	2.25	1.00	2.05
2.20	0.85	1.62	2.40	1.05	2.00
1.95	0.80	1.80	2.45	1.20	2.10
2.00	1.00	1.80	2.50	1.35	2.15
2.25	0.95	1.70	2.30	1.30	2.00
2.05	0.85	1.70	2.40	1.20	2.30
2.20	1.00	1.75	2.30	1.20	2.15
2.40	1.00	1.70	2.45	1.20	2.25
2.05	0.90	1.70	2.50	1.35	2.20
2.30	1.05	1.75	2.60	1.25	2.00
2.05	0.95	1.80	2.55	1.20	2.15
2.00	0.85	1.70	2.80	1.30	1.95
1.90	0.80	1.80	2.35	1.20	2.15
2.20	0.90	1.68	2.45	1.10	2.20

∴ M/s / (Anal spine = 10) = 13/5

∴ M/s/ (Anal spine = 10) = 12/6

## APPENDIX II

### *Meaning of Symbols used in Tables 4, 5, 6, 7, 8, 9, 10 and 11*

- a* = I internal segment (ventral surface).
- b* = Anterodorsal head.
- c* = Posterodorsal head.
- d* (1) = "m" seta on the tergite of Th I.
- d* (2) = Posterior half of the tergite of Th. I.
- d* (3) = Anterior half of the tergite of Th. I.
- e* = Subcoxa I.
- f* (1) = Outer two rows of dorsomedian part of Abd. II.
- f* (2) = "S" Setae on the tergite of Abd. II.
- f* (3) = Inner two rows of dorsomedian part of Abd. II.
- g* (1) = Outer two rows of dorsomedian part of Abd. IV.
- g* (2) = Dorsomedian part of Abd. IV.
- g* (3) = Inner two rows of dorsomedian part of Abd. IV.
- h* (1) = Dorsomedian part of Abd. V.
- h* (2) = "S" setae on the tergite of Abd. V.
- h* (3) = Setae "t" + "s" on the tergite of Abd. V.
- i* = Tergite of Abd. VI.
- j* = Ventral tube.
- j* (1) = Base of ventral tube.
- j* (2) = Anterior seta or ventral tube.
- j* (3) = Distal outer row of ventral tube.
- j* (4) = Distal inner row of ventral tube.
- k* (1) = Upper anal valve.
- k* (2) = Outer semicircular margin of upper anal valve.
- k* (3) = Sternite of Abd. II.
- l* = Ventral organ.
- l* (1) = Inner tooth in unguis.
- l* (2) = Lateral tooth in unguis.
- l* (3) = Pseudocelli over the body.
- l* (4) = Pseudocelli over Subcoxa I.
- m* = Genital aperture.

*N.B.*—Lettering of setae is after Gisin.

# APPENDIX III

## *Meaning of Symbols used in Table 10*

Column	Symbol	Type	Column	Symbol	Type
1	<i>a</i>	Fimatus	6	<i>a</i>	Fimatus
	<i>b</i>	Parthenogeneticus		<i>b</i>	Campatus
2	<i>a</i>	Fimatus	7	<i>a</i>	Fimatus
	<i>b</i>	Humatus		<i>b</i>	Campatus
	<i>c</i>	Aurantiacus		<i>c</i>	Waterstoni
	<i>d</i>	Bicampatus		<i>d</i>	Parthenogeneticus
	<i>e</i>	Parthenogeneticus		<i>e</i>	Hortensis
	<i>f</i>	Furciferus	8	<i>a</i>	Fimatus
3	<i>a</i>	Fimatus		<i>b</i>	Campatus
	<i>b</i>	Waterstoni	9	<i>a</i>	Fimatus
	<i>c</i>	Parthenogeneticus		<i>b</i>	Subarmatus
	<i>d</i>	Furciferus		<i>c</i>	Aurantiacus
	<i>e</i>	Halophilus		<i>d</i>	Furciferus
4	<i>a</i>	Fimatus		<i>e</i>	Parthenogeneticus
	<i>b</i>	Aurantiacus	10	<i>a</i>	Fimatus
	<i>c</i>	Bicampatus		<i>b</i>	Parthenogeneticus
	<i>d</i>	Parthenogeneticus			
5	<i>a</i>	Fimatus	11	<i>a</i>	Fimatus
	<i>b</i>	Armatus		<i>b</i>	Campatus
	<i>c</i>	Campatus		<i>c</i>	Halophilus

# APPENDIX IV

## *Meaning of Symbols used in Table 11*

Column	Symbol	Type	Column	Symbol	Type
1	<i>a</i>	Imperfectus	6	<i>a</i>	Imperfectus
2	<i>a</i>	„		<i>b</i>	Pygmaeus
3	<i>a</i>	„	7	<i>a</i>	Imperfectus
	<i>b</i>	Stachianus		<i>b</i>	Gotoi
4	<i>a</i>	Imperfectus		<i>d</i>	Stachianus
	<i>b</i>	Stachianus	10	<i>a</i>	Imperfectus
5	<i>a</i>	Imperfectus	11	<i>a</i>	„
				<i>b</i>	Stachianus
				<i>d</i>	Gotoi

### Summary :

This communication presents results of the taxonomic observations on the thirty eight nominal British species mainly of the "armatus" and "fimetarius" groups. Of them eleven species, such as *O. uliginatus* and *O. sublatus*; *O. flavidulus* and *O. latus*; *O. s-vontornei*; *O. procampatus*; *O. evansi*; *O. scoticus*; *O. celticus* and *O. subequalis*; and *O. pseudostachianus* are sunk as synonyms of *O. waterstoni*, *O. aurantiacus*, *O. humatus*, *O. campatus*, *O. moniezi*, *O. furciferus* and *O. stachianus* respectively for two reasons: (i) most of the systematic criteria of Bagnall and Gisin when critically examined are found to be of very limited or of no taxonomic value and (ii) the erection of these species is based on the highly variable characters, such as colour of the body, number of vesicles in P. A. O., pseudocelli over the whole of the body, relative lengths of some setae and anal spines, chaetotaxy on the tergite of Th. I, teeth on the unguis etc. On the contrary, some chaetotactic characters introduced, for the first time here, have proved to be of greater constancy and are of wider taxonomic value since many of them can be employed even in case of the juveniles. A dichotomous key to the twenty seven hitherto considered valid species of the British Isles is also included.

### Acknowledgments :

The author is indebted to his teacher, Prof. O. W. Richards, F. R. S. and Mr. H. E. Goto of Imperial College of Science and Technology, London and to Dr. H. Gisin, Natural History Museum, Geneva for their valuable criticisms and unstinting help throughout this work.

### References :

- Absolon, K. Weitere Nachricht über europäische Hohlencellemnaden und über die Gattung *Aphorura* A. D. Macgill. *Zool. Anz.*, **24** : 375-381, 385-389, 1901.
- Bagnall, R. S. Notes on British Collembola II. *Ent. mon. Mag.*, **71** : 61-68, 1935a.
- Contributions towards a knowledge of the Scottish Onychiuridae (Collembola). (I) *Scot. Nat.*, **214** : 111-117, 1953b.
- Contributions towards a knowledge of the Scottish Onychiuridae (Collembola). II. *Ibid.*, 87-90, 145-150, 1937.
- Notes on British Collembola III-VII. *Ent. mon. Mag.*, **75** : 21-28, 56-63, 91-102, 188-200, 1939.
- Contributions towards a knowledge of Onychiuridae (Collembola-Onychiuroidea) I-IV. *Ann. Mag. Nat. Hist.*, S. 11, **14** : 631-642, 1947.
- Contributions towards a knowledge of the Onychiuridae (Collembola-Onychiuroidea) V-X. *Ibid.*, S. 12, **2** : 498-511, 1949.
- Börner, C. Vorläufige Mitteilung über einige neue Aphorurinen und Zur Systematik der Collembola. *Zool. Anz.*, **24** : 1-15, 1901a.
- Über einige theilweise neue Collembolen aus den Höhlen der Gegend von Letmathe in Westfalen. *Ibid.*, 333-345, 1901b.
- Neue Collembolenformen und Zur Nomenclatur der Collembola Lubb. *Ibid.*, 696-712, 1901c.

- Choudhuri, D. K. On two new species of *Onychiurus* Gervais, (Collembola: Onychiuridae) from the British Isles. *Proc. R. Ent. Soc. Lond.*, (B) 27: 155-159, 1958.
- On a neglected species of the genus *Onychiurus* (Collembola). *Proc. Zool. Soc.*, 15: 43-45, 1962.
- On the controversy between *Onychiurus burmeisteri* (Lubbock, 1873) and *O. tuberculatus* (Moniez, 1891). *Proc. Zool. Soc.*, 16: 93-95, 1963a.
- Temperature and its effect on the three species of the genus *Onychiurus*. *Proc. Zool. Soc.*, 16: 97-117, 1963b.
- Revision of Bagnall's work on the genus *Onychiurus* (Collembola). *Proc. Nat. Acad. Sci. India*, (B) 33: 329-341, 1963c.
- Denis, J. R. Notes sur les Aptérygotes. I. Sur quelques Aptérygotes décrits par M. Moniez. II. Sur La faune française des Aptérygotes (V). *Ann. Soc. ent. France*, 92: 209-246, 1923.
- Collembolles d'Italie (principalement cavernicoles). (Sur la faune italienne des Collembolles VI. (recte: VII) Trieste. *Boll. Soc. Adriat. Sci. nat.*, 36: 95-165, 1938.
- Folsom, J. W. North American Collembolous insects of the subfamily Onychiurnae. *Proc. U. S. nat. Mus.*, 53: 637-659, 1917.
- Gervais, P. *Onychiurus* n.g. *Echo Monde. Sav.*, 8: 372, 1841.
- Gisin, H. Notes sur les Collembolles avec description de quatorze espèces et d'un genre nouveaux. *Mitt. Schweiz. ent. Ges.*, 22: 385-410, 1949.
- Notes sur les Collembolles, avec demembrement des *Onychiurus armatus*, *ambulans* et *finetarius* auctorum. *Mitt. Schweiz. ent. Ges.*, 25: 1-22, 1952a.
- *Onychiurus vanderdrifti* n.sp. (Collembola). *Ent. Ber.*, 14: 61, 1952b.
- Description de cinq espèces inédites de Collembolles. *Mitt. Schweiz. ent. Ges.*, 27: 49-52, 1954.
- Nouveaux contributions au demembrement des espèces d'*Onychiurus* (Collembola). *Ibid.*, 29: 329-352, 1956.
- Hammer, M. Investigations on the microfauna of Northern Canada. Part 2 (Collembola). *Acta arct.*, 6: 1-108, 1953.
- Handschin, E. Die Onychiurinen der Schweiz. *Verh. Naturf. Ges. Basel.*, 32: 1-37, 1920.
- Linnaeus, C. *Syst. Nat.* (ed. 10), I: 608, 1758.
- Lubbock, J. Monograph of the Collembola and Thysanura. *Ray. Soc.*, pp., 276, 1873.
- Ridley, H. N. A new species of *Lipura*. *Ent. mon. Mag.*, 17: 1-2, 1880.
- Schött, H. Kamerunische Collembolen. *Jber. Gymn. Linköping*, pp., 40, 1927.
- Stach, J. Die in den Höhlen Europas vorkommenden Arten der Gattung *Onychiurus* Gervais. *Ann. Mus. Zool. Polon.*, 10: 112-222, 1934.
- The Apterygotan fauna of Poland in relation to the World-fauna of this group of insects. Fam. Onychiuridae. *Polska Akademia Nauk. Inst. Zool. Krakow.*, 1954.
- Tullberg, T. Om skandinaviska podurider af underfamiljen Lipurinae. *Diss. Upsala.*, pp., 21, 1869.

# STUDIES ON THE INFLUENCE OF SOIL-MOISTURE REGIMES ON PHOTOSYNTHESIS AND RESPIRATORY ACTIVITIES OF BOTTLE GOURD (*LAGENARIA SICERARIA* L.)\*

By

R. N. SINGH\*\*

*College of Agriculture, Banaras Hindu University, Varanasi*

[Received on 12th March, 1964]

## Introduction :

In recent years numerous reviews have been published on the effect of soil moisture regimes on the development and growth of plants (Kramer, 1956 ; Kursanov, 1956 ; Slatyer, 1957 ; Oppenheimer, 1961 ; Stocker, 1961 ; etc.) but its relation with respect to metabolic activities has not been precisely investigated. It is now known that the deficiency of soil moisture produces subnormal influence on photosynthesis (Thoday, 1910 ; Briggs and Shantz, 1912 ; Dastur, 1924 ; Pentinov, 1938 ; Simonis, 1947 ; Ghose, 1949 ; Negisi and Satoo, 1954 ; Stoev and Magriso, 1955 and Babaeva, 1956) though no such effect was encountered by Wood (1929) and rather an improvement by Luciano and Silino (1952). The respiration rate is also depressed (Singh and Varadpande, 1930 ; Larmour *et al*, 1944 and Olafson *et al*, (1954). In the present state of information, it was considered interesting to understand precisely the effect of different soil-moisture regimes (ranging from field capacity to wilting range) on plant growth, photosynthesis and respiratory activities of bottle gourd (*Lagenaria siceraria* L). which is widely grown as vegetable crop during the rainy season.

## Material and Methods :

Seedlings of bottle gourd were raised in earthenware pots filled with garden soil and were transplanted when 15 cm. tall to previously prepared pots through the rubber tubing attached with a tin cover. Watering was maintained at optimum level till the 43rd day after sowing when different regimes of watering were initiated. Five treatments were adopted, including daily watering (D.W.), biweekly watering (B.W.W.), weekly watering (W.W.), fortnightly watering (F.W.) and no watering (N.W.), and 10 pots were allotted for each of them. Observations at weekly intervals on the rate of photosynthesis and respiration were taken and expressed as the uptake or output of CO<sub>2</sub> in mgs per 100 cm<sup>2</sup> of plant area on hourly basis. The apparatus for the above studies was designed by Gupta (1961) based on the techniques described by Porter *et al*, (1950) and Gregory *et al*, (1954). In addition to the above, data on total leaf area, fresh and dry weight of shoots were also collected.

## Experimental findings :

**Growth and leaf area :** The results on leaf area and fresh and dry weight of the shoot are presented in Table I.

\*A part of the thesis approved for M.Sc. (Agri.) degree of the Banaras Hindu University (1961).

\*\*Present Address : Division of Botany, Indian Agricultural Research Institute, New Delhi-12.

TABLE I  
Influence of varying soil-moisture levels on plant growth of bottle gourd  
(Mean per plant)

Days after sowing	Watering regimes					Mean
	D.W.	B.W.W.	W.W.	F.W.	N.W.	
<i>(i) Leaf area in cm<sup>2</sup></i>						
50	559.39	339.54	337.18	250.39	157.85	328.87
57	1483.93	1408.44	512.67	411.70	219.91	807.33
64	1363.30	646.80	460.20	364.10	285.20	623.92
71	1174.12	473.40	250.17	132.05	77.72	421.49
78	433.75	267.50	150.05	93.75	—	236.26
Mean	1002.89	627.13	342.05	250.39	185.17	
<i>(ii) Fresh weight in mgs</i>						
50	1527	947	895	675	530	914.80
57	4750	4565	1850	1270	757	2638.40
64	4860	2330	1630	1295	1107	2244.40
71	4550	1624	1245	852	257	1705.60
78	3490	1630	1000	580	—	1675.00
Mean	3835.40	2219.20	1324.00	934.4	662.75	
<i>(iii) Dry weight in mgs</i>						
50	104	92	88	62	50	79.20
57	364	367	192	89	39	210.20
64	462	207	207	108	119	220.60
71	507	164	126	77	29	180.60
78	407	166	119	57	—	182.25
Mean	368.80	199.20	146.40	78.60	59.25	

From Table I it is clear that the maximum expansion of the foliage was attained in about 57 days after sowing, beyond which a decline was evident owing to the shedding of the older leaves. This was found to coincide with the onset of the flowering phase. The drying up and subsequent abscission of the older leaves was relatively higher in the treatments with wider watering intervals. Similar trends were discernible for fresh and dry weights of the shoots. It is interesting to observe wider variations with respect to dry matter produced by 100 cm<sup>2</sup> leaf area grown under different moisture regimes, as would be noticed from the data presented in Table II.

TABLE II

*Effect of different soil-moisture levels on dry weight of leaves in bottle gourd (expressed as dry weight (in mgs) per 100 cm<sup>2</sup> of the leaf surface)*

Days after sowing	Watering regimes					Mean
	W.D.	B.W.W.	W.W.	F.W.	N.W.	
50	9	14	13	12	15	13
57	13	13	19	11	12	13
64	17	16	23	15	21	18
71	22	17	25	29	19	22
78	47	31	40	30	—	37
Mean	21	18	24	19	17	

## RESPIRATION AND PHOTOSYNTHESIS

TABLE III

*Effect of different soil-moisture regimes on rates of photosynthesis and respiration in bottle gourd. (expressed as CO<sub>2</sub> uptake or output in mg. per 100 cm<sup>2</sup> leaf area in one hour)*

Days after sowing	Watering regimes					Mean
	D.W.	B.W.W.	W.W.	F.W.	N.W.	
(i) <i>Photosynthesis</i>						
50	3.60	4.06	6.44	5.80	4.87	4.95
57	6.91	7.44	8.41	7.45	4.95	7.03
64	8.84	10.50	11.41	9.90	5.95	9.32
71	10.35	11.95	11.95	10.00	5.50	9.75
78	11.70	12.58	14.25	10.15	—	12.17
Mean	8.28	9.10	10.49	8.66	5.32	
(ii) <i>Respiration</i>						
50	2.35	2.55	4.23	3.75	3.65	3.30
57	4.55	4.95	5.45	5.20	3.50	4.73
64	5.35	6.75	7.21	6.70	3.40	5.88
71	6.60	7.00	7.45	6.65	3.25	6.19
78	7.20	7.30	8.30	6.60	—	7.35
Mean	5.21	5.71	6.53	5.78	3.45	

From the data presented in Table III it is clear that photosynthetic and respiratory activities exhibited an upward trend with increase in plant age. Different watering levels also indicated their varied responses.

**Photosynthesis :** The photosynthetic rate exhibited an upward trend till 64 days after sowing, following which it fell in the sets receiving no water-supply, whereas in the rest of the treatments upward rise continued till the expiry of the experiment. The rate was maximum in the plants watered at weekly intervals, the difference between daily and biweekly water regimes were comparatively small, although the latter had a distinctly higher rate.

**Respiration :** Similar to photosynthesis, the maximum respiratory activity was encountered in the weekly watered set. It is interesting to notice comparatively higher respiration rates in fortnightly and no watering sets during the first two weeks of experiment, following which downward trend was observed.

#### Discussion :

From the results summarized in the preceding section, it is seen that the maximum leaf area, fresh weight and dry weight of plant tops were recorded in the sets receiving daily watering. A tendency to decrease with wider watering intervals was also noticed. On the other hand, the photosynthetic and respiratory activities were the highest in the weekly watering set. A comparison in the photosynthetic and respiratory rates under daily and weekly watering regimes is presented in Table IV.

TABLE IV  
*Comparison of photosynthesis and respiration rates in daily and weekly watering sets*  
(Mean per plant)

Treatment	Time interval after sowing			
	50-57	57-64	64-71	71-78
(i) <i>Photosynthesis</i>				
D.W.	3.31	1.93	1.51	1.35
W.W.	1.97	3.00	0.54	2.30
(ii) <i>Respiration :</i>				
D.W.	2.20	0.80	1.25	0.60
W.W.	1.22	1.76	0.24	0.85

From the above observations a progressive decrease in the assimilatory power of the daily watered set was quite obvious. On the contrary, in the weekly watered set inconsistent trends of increase and decrease were seen. Similar pattern was also noticed in the respiratory activity. It is possible that wider changes in the hydration capacity of weekly watered plants caused by larger shifts in soil-moisture content (from field capacity of about 30 per cent to 13.5 per cent) results in metabolic patterns consisting of activated enzyme systems. Such suggestions have been advanced by Stocker (1948) and Northen (1943). Depression in photosynthetic and respiratory activities in fortnightly and no-watering sets might have been caused by extreme desiccation of the metabolizing cells.

Another interesting feature emerging from the present study relates to the relationship between soil-moisture content, leaf area and metabolic activities of plant. Soil-moisture appears to exert a direct influence on leaf expansion which is suppressed under low water supply, but a similar depression in the photosynthetic and the respiratory activities was not discernible.

### Summary :

Influence of five different watering regimes on growth, photosynthesis and respiration of bottle gourd (*Lagenaria siceraria* L.) was studied in pot cultures. The results indicate differences in growth and related metabolic activities. Photosynthesis and respiration were highest when watering was allowed at weekly intervals. On the other hand the plant growth indicated by total leaf area of the foliage and fresh and dry weights of the plant-tops was maximum under the condition of daily watering. The significance of the results is discussed.

### Acknowledgements :

The author is grateful to Professor K. Kumar for guidance and keen interest shown during the progress of the work. His thanks are due to Dr. R. S. Choudhri for providing the necessary facilities and encouragement.

### References :

- Babaeva, A. M. The influence of watering on the photosynthesis of tea plants. *Doklady Akad. Nauk. A. zerbaidzhen U. S. S. R.*, No. 12 : 993-98, 1956.
- Briggs, L. J. and Shantz, M. L. The wilting co-efficient and its indirect determination. *Bot. Gaz.*, **53** : 20-37, 1912.
- Dastur, R. H. Water content a factor in photosynthesis. *Ann. Bot.*, **38** : 779-88, 1924.
- Ghose, B. N. Physiological studies on the effect of varying water on growth of rice in relation to carbohydrate metabolism of the leaf. *Bull. Bot. Soc. Bengal*, **3** (1) : 1-8, 1949.
- Gregory, F. G., Spear, I. and Thimann, K. V. The interrelation between CO<sub>2</sub> metabolism and photoperiodism in *Kalanchoe*. *Plant Physiol.*, **29** (3) : 202-29, 1954.
- Gupta, U. S. Apparatus for the measurement of respiration and photosynthesis of two intact plants. *Jour. Sci. Res. B. H. U.*, **XI** (2) : 317-320, 1961.
- Kramer, P. J. The uptake of water by plant cells. *Encycl. Pl. Physiol.* Ed. W. Ruhland, Springer Verlag, Berlin., Vol. II : 316-36, 1956.
- Kursanov, A. L. Recent advances in plant physiology in the U. S. S. R. *Ann. Review of Plant Physiol.*, Vol. 7 : 401-422, 1956.
- Larmour, R. K., Sallanee, M. R. and Graig, B. M. Respiration of whole and dehulled sunflower seed and of flax seed. *Canadian Jour. Res. Sect. F. Technical*, **22** (1) : 9-18, 1944.
- Northern, H. T. In P. J. Kramer's article on water content and water turnover in plant cell. *Encycl. Pl. Physiol.* Ed. W. Ruhland, Springer Verlag, Berlin, Vol. 1 : 194-240, 1943.
- Negisi and Satoo, T. The effect of drying of soil on apparent photosynthesis, transpiration carbohydrates reserve and growth of seedling of Akamatu. *Pinus densiflora* Sieb et Zucc. *Jour. Japanese Forest Soc.*, **36** (3) : 66-71, 1954.
- Olafson, J. H., Christensen, C. M. and Geddes, W. F. Influence of moisture content commercial grade and maturity on the respiration and chemical deterioration of Corn. *Cereal Chem.*, **31** : 330-40, 1954.

- Oppenheimer, H. R. Review of research in Israel on plant water relations. *Indian Jour. Plant Physiol.*, **4** : 1-10, 1961.
- Pentinov, N. S. The effect of continuous and discontinuous water supply on the photosynthetic process and yield of summer wheat. *Compt. Rend. (Doklady) Akad. Soc. U. S. S. R.*, **1B** (1) : 69-73, 1938.
- Porter, H. K., Pal, N. and Martin, R. V. Physiological studies in plant nutrition XV. Assimilation of carbon by the ear of barley and its relation to the accumulation of dry matter in the grain. *Ann Bot. (Lond.)* **14** : 55-68, 1950.
- Singh, B. N. and Varadpande, K. V. Studies in respiration of tropical plants. Effect of injecting water, glucose and phosphates on a failing system of respiration in the leaves of *Artocarpus integrifolia* and its significance on the mechanism of respiration. *Proc. Indian Sci. Congress*, **17** : 311-12, 1930.
- Luciano, T. and Silino, F. Photosynthetic activity respiratory intensity, reduced glutathione, ascorbic acid and calatax activity as affected the soil water supply. *Ann. Sper. Agr. (Roma)*, **6** : 461-79, 1952.
- Simonis, W. Carbon dioxide assimilation und stoff produktion trocknen gezogener Pflanzen. *Planta*, **35** : 188-224, 1947.
- Stocker, O. In P. J. Kramer's article on water content and water turnover in plant cells. *Encyl. Pl. Physiol.* Ed. W. Ruhland, Springer Verlag, Berlin. **Vol. I** : 194-240, 1948.
- Contribution to the problem of drought resistance of plants. *Indian Jour. Plant Physiol.*, **4** : 87-102, 1961.
- Slatyer, R. O. The significance of permanent wilting in studies of plant and soil water relation. *Bot. Rev.*, **23** : 587-636, 1957.
- Stoev, K. D. and Magriso, Yu. N. Effect of irrigation on the course of physiological process and crop yield on the grape vine. *Fiziol. Rasten*, **2** : 565-72, 1955.
- Thoday, D. Experimental studies on vegetable assimilation and respiration. *Proc. Roy. Soc. (Lond.)*, B. **82** : 1-55, 1910.
- Wood, J. G. The relation between water content and amount of photosynthesis. *Australian Jour. Expt. Biol. and Med. Sci.*, **6** (2) : 127-131, 1929.

# LEAF CURL OF *VINCA ROSEA* AND *V. ROSEA* VAR. *ALBA*

By

N. S. BISHT and D. V. SINGH

Laboratory of the Plant Pathologist to Government, Uttar Pradesh, Kanpur

[Received on 21st January, 1964]

## Introduction :

Garg (1958) reported green rosette of *Vinca rosea* L. in Madhya Pradesh characterized by extreme shortening of lateral branches and sub-branches, reduction in the size of leaves and their assemblage thus giving rosetted appearance with reduction in size of flowers.

In December, 1962 characteristic symptoms of leaf curl, crumpling and mosaic of leaves of *Vinca rosea* L. and *V. rosea* var. *alba* L. were observed in a few potted plants at the Government Agriculture College, Kanpur. Affected branches were reduced in size and apical growth stopped. Diseased leaves were twisted, curled and greatly reduced in size showing pale green streaks accompanying the veins (Fig. 1). Leaves at the apex of the branches showed more severe symptoms than those situated below and some of the leaves at the base of the branches were found apparently healthy thus suggesting cumulation of symptoms at the tip of the infected branches. This was confirmed by transmission studies. Both apparently healthy and diseased branches were frequently observed in the same plant. Flowers were considerably reduced in size showing discolouration and were faded.

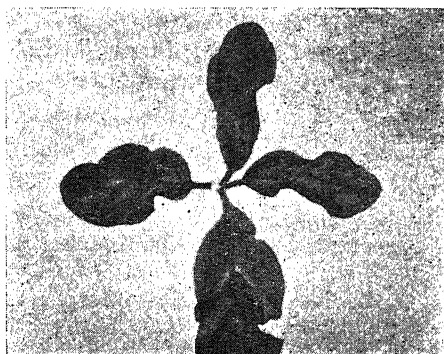


Fig. 1. Diseased leaves of *Vinca rosea* showing curling and mosaic symptoms.

## Experimental Results :

Attempts were made to transmit the virus to healthy *Vinca rosea* and *V. rosea* var. *alba* plants by sap inoculation, by dusting carborundum powder on the leaves of healthy plants and rubbing with sap of the diseased plants. The disease was not transmitted by sap inoculation. However, it was transmitted by cleft grafting thus establishing the virus nature of the disease. The new shoots arising from

the stock developed characteristic symptoms after a month of grafting. The virus was more readily transmitted from severely infected twigs than from apparently healthy parts of the same plant. Dodder transmission was tried by first establishing the *Cuscuta* sp. on diseased *V. rosea* plants and then allowing it to spread on healthy plants of *V. rosea* but got negative results. As white fly (*Bemisia tabaci* Gen.) is known to transmit several leaf curl diseases of virus origin in India, it was tried as a probable vector but it failed to transmit the virus.

Host-range studies were carried out by grafting the diseased scions to *Nicotiana rustica* L., *Datura stramonium* L., *Lycopersicum esculentum* Mill., *Petunia hybrida* Vilm., *Solanum melongena* L., *Capsicum annuum* L., *Impatiens balsamina* L., *Nicandra physaloides* L., *Vigna sinensis* L., *Arachis hypogaea* L. and *Cucumis sativus* L. but the virus could not be transmitted to these plants although the grafts were successful in all the cases.

#### **Discussion :**

This disease resembles to some extent the rosette of *Vinca* in stunting of leaves, twigs and flowers but differs markedly by the presence of pale green streaks accompanying veins, curling, crumpling and twisting of leaves and discolouration of flowers. All the more there is no rosetting at all in this disease. It is inferred that the disease under report is distinct from the green rosette of *V. rosea* described by Garg (1958).

#### **Summary :**

Leaf curl of *Vinca* characterized by curling, crumpling and mosaic of leaves along with reduction in the size and discolouration of flowers has been described for the first time. The virus was transmitted only by grafting to healthy *Vinca* plants. It could not be transmitted by dodder (*Cuscuta* sp.), white flies and sap inoculation.

#### **Acknowledgement :**

Thanks are due to Dr. R. S. Mathur, Plant Pathologist to Government, Uttar Pradesh, Kanpur for useful suggestions and encouragement.

#### **Reference :**

- Garg, R. P. Studies on virus diseases of plants in Madhya Pradesh I Green Rosette of *Vinca*, *Curr. Sci.*, 27 (12) : 493-494, 1958.

# THE MORPHOLOGY AND ANATOMY OF THE CAPITULUM OF *ACANTHOSPERMUM HISPIDUM* DC.

By

Y. D. TIAGI and K. S. MANILAL

Department of Botany, University of Saugar, Saugar (M.P.), India

[Received on 16th May, 1964]

*Acanthospermum* Schrank is a genus of the family Compositae comprising about five species in Tropical America and the Galapagos (Willis, 1931). There is practically no account of the morphology and anatomy of the capitulum of this genus. Recent studies on the floral morphology of the family Compositae in this laboratory showed that the capitulum of *Acanthospermum* is compound. This encouraged us to investigate its morphology in detail and the results are presented hereto.

## Material and Method :

*Acanthospermum hispidum* is locally available in abundance, especially during and after the monsoons, although stray plants are seen in favourable situations throughout the year. In fact at many of the places, it has been replacing the equally notorious weed, *Cassia tora*. Gamble (1921) who found *Acanthospermum hispidum* in the South Canara and Salem Districts of Madras State comments that it is a South American introduced plant and that it is likely to become common.

Material was fixed in FAA from plants growing in the University Campus. Customary methods of microtechnique were employed and serial transverse and longitudinal sections of the capitulum were cut at thickness ranging from 25–40 $\mu$ . Staining combinations used were crystal violet-erythrosin and safranin-fastgreen.

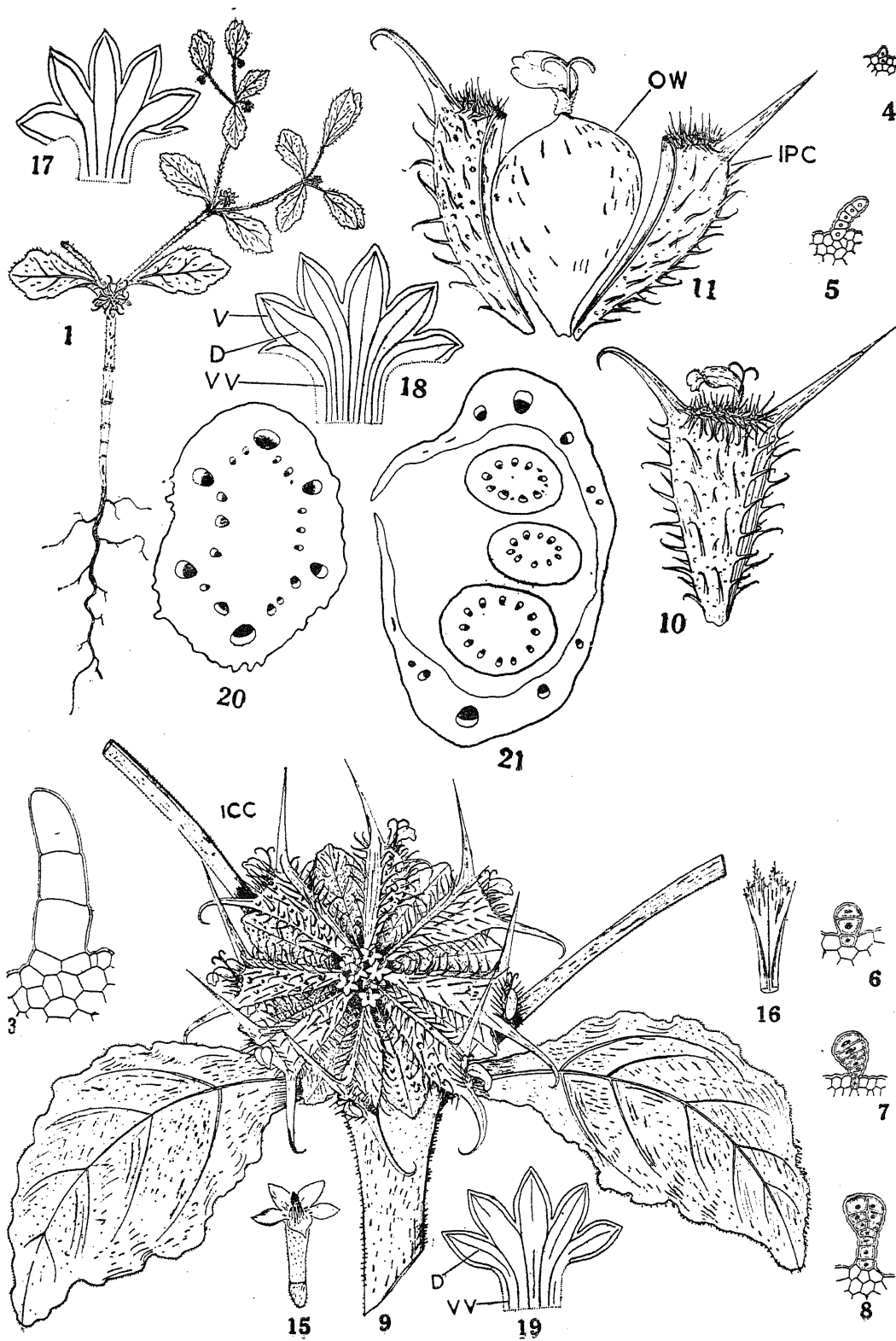
## Observations :

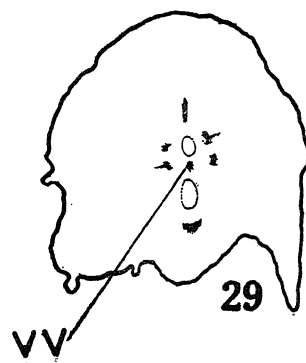
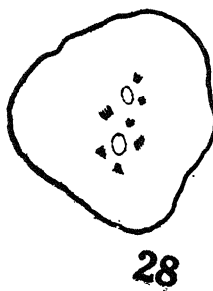
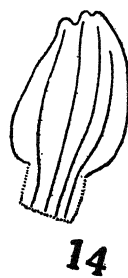
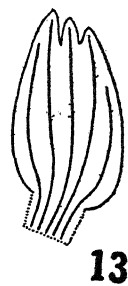
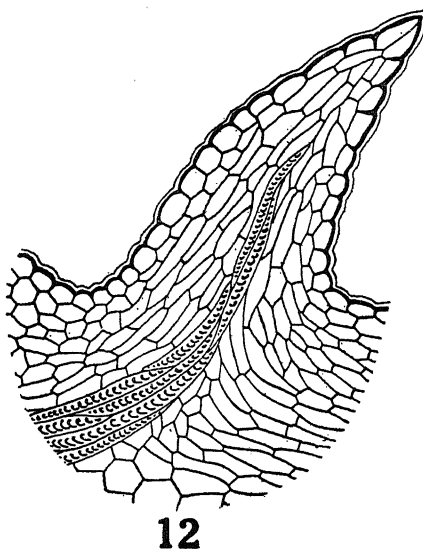
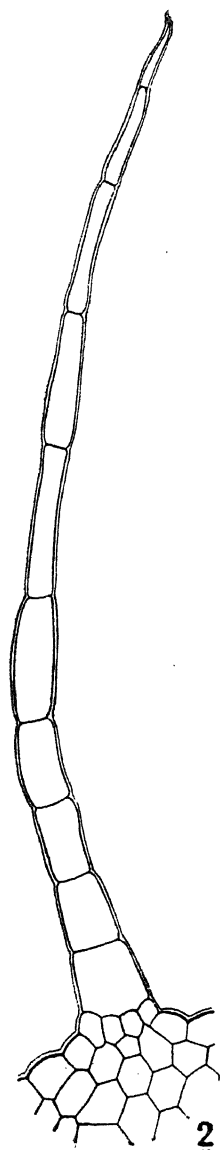
**External Morphology.**—*Acanthospermum hispidum* is an erect, hispid, pseudodichotomously branched herb (Fig. 1) with a maximum height of about 120 cm. The leaves are borne in opposite-decussate manner. The leaf bases of the two members of a pair are united to form a thin frill around the node. The leaves are simple, sessile, obovate, sparsely dentate, hairy and acute. The trichomes are long, multicellular-uniseriate with a multiseriate basal layer and a long tapering apical cell (Fig. 2). Multicellular-uniseriate hairs of various sizes but comparatively smaller than the previous one and with rounded apices occur on the peduncle of the capitulum, on the leaf (Fig. 3) and the involucre of the peripheral capitula of the compound capitulum (Figs. 4–5). In addition to these types, multicellular trichomes with multiseriate, swollen, glandular heads and uniseriate stalks also occur on the outer surface of the involucre of the female, peripheral capitula, corolla of both the outer female and the central male florets and the paleae of the latter (Figs. 6–8).

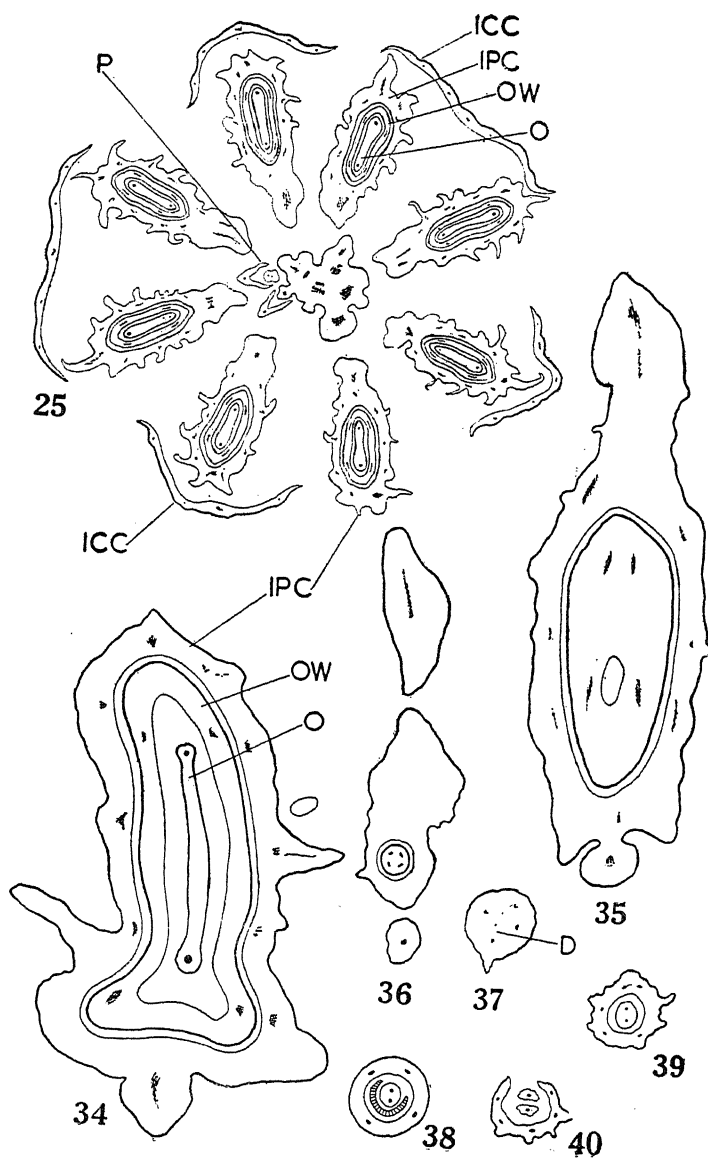
After bearing 5 to 9 pairs of leaves, the terminal bud of the shoot grows into a compound capitulum. The axillary buds of the uppermost pair of leaves continue the further growth and each after producing a pair of leaves terminates into a compound capitulum and this mode of growth is continued throughout the life of the plant. The whole plant, thus becomes a dichasial cyme of capitula (Figs. 1, 9) with the planes of successive branchings at right angle to each other. When the capitula in the forks of the branches dry up and fall down, the plant seemingly looks 'dichotomously' branched.

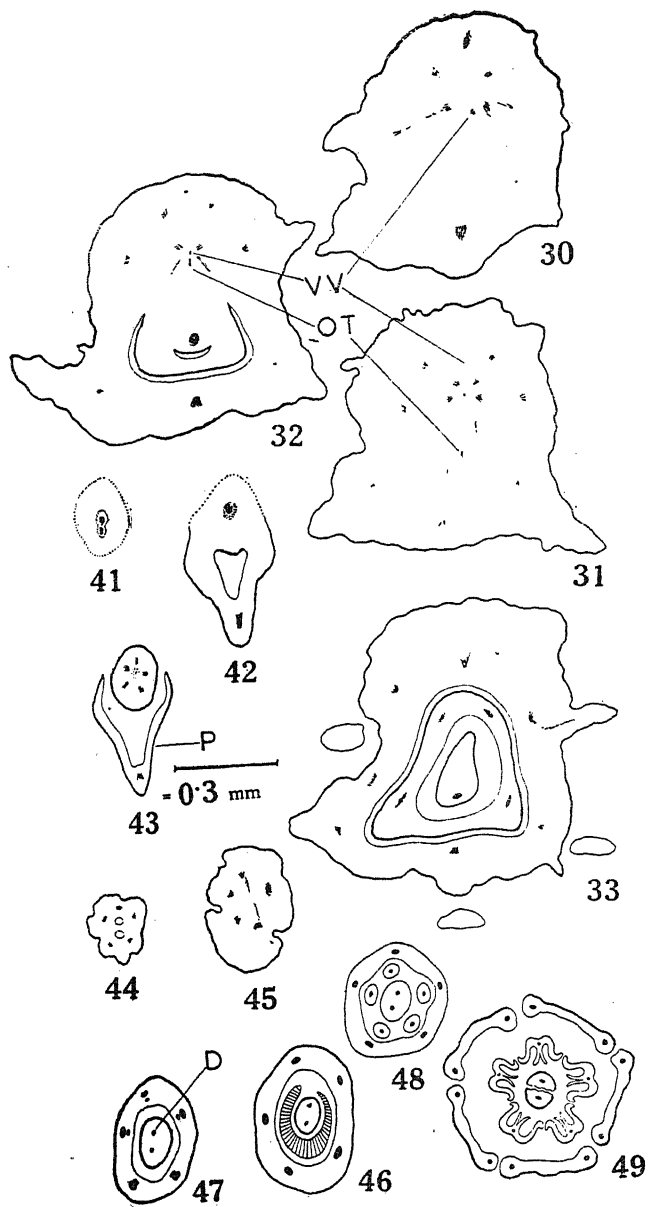
The involucre of the compound capitulum consists of 5, hairy bracts which are slightly united in their basal parts. Inside the involucre, there are 5 to 9, unifloral capitula of female sex and a central capitulum of about 7 florets of male sex (Figs. 9, 23-25, 50-51). Each peripheral capitulum consists of a short, thick, more or less horizontal stalk and an obconic, laterally flattened involucre. The latter is furnished with spines having recurved tips all over its surface (Figs. 9-12). There are two long spines at the top of the involucre; that on the posterior side being more or less straight or slightly arched and that on the anterior side being the longer and strongly curved outward, downward and inward, especially during the later stages (Figs. 9, 10-11). In its general construction, the involucre of the peripheral capitula of the compound capitulum of *Acanthospermum hispidum* is similar to that of the female capitula of *Xanthium strumarium*, the difference being in the presence of two apetalous florets in the latter and of only one floret with ligulate corolla in the former. The single female floret contained inside the involucre has a laterally flattened, obovate ovary bearing at its top a small ligulate type of yellow-coloured corolla. The latter has a small tube and a somewhat 3-lobed ligule (Figs. 9-11). Inside the corolla, 4 to 5 vascular bundles are seen (Figs. 13-14). The style is terete and is tipped by the two, medianly placed, long stigmatic lobes of which the anterior one is straight and slightly longer than the posterior one which is bent inward and downward. A swollen, yellow-coloured nectar disc is present at the base of the style. The corolla tube projects out of the involucre through an opening in its apex (Figs. 11, 50). There is a single, basal, unitegmatic, anatropous type of ovule inside the ovary.

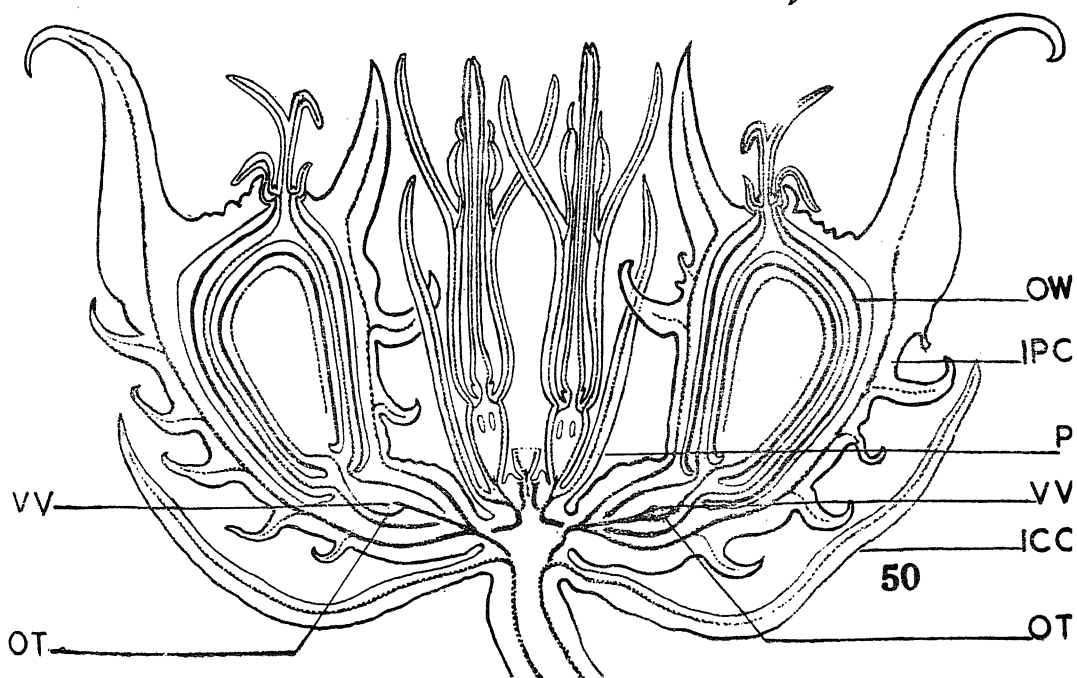
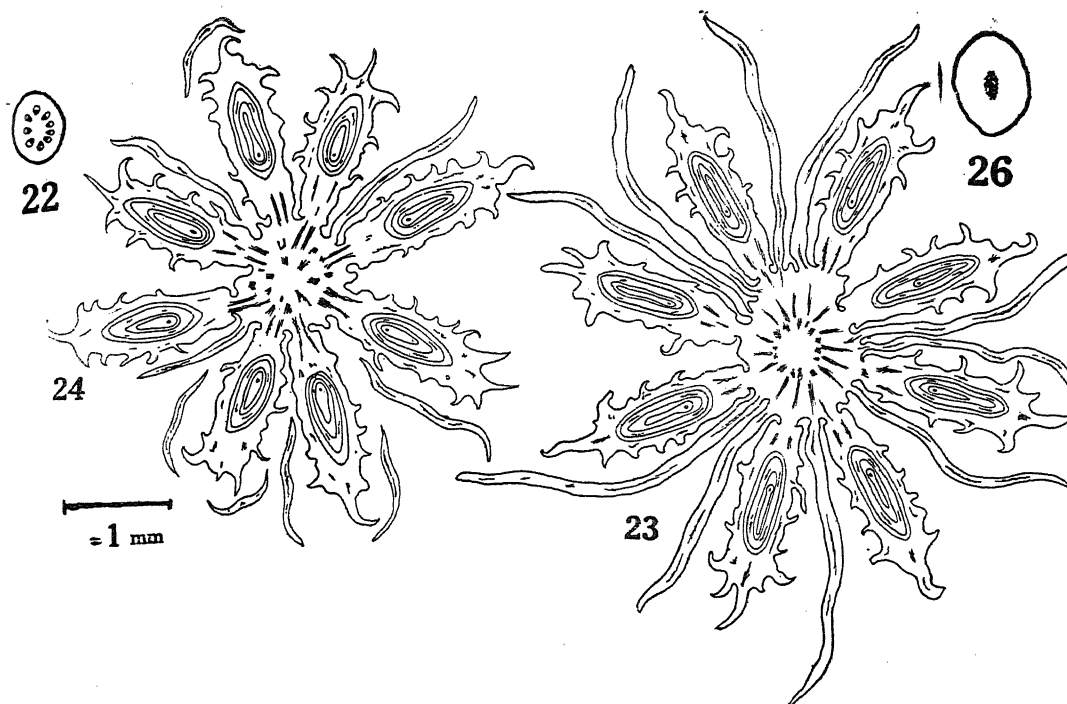
The central capitulum consists of about 7, male florets. The basal part of each is enveloped by its delicate, membranous palea which is irregularly fimbriated above with each segment tipped by a glandular hair (Fig. 16). The lower ovary-like part of the floret is almost solid, showing only two small vestigial loculi in the upper part but no ovules (Figs. 44, 50). The corolla is yellow, campanulate and 5-lobed at the apex (Fig. 15). Generally there are only 5 compound marginal bundles inside the corolla and situated on the same radii as the sinuses above. Below the sinuses, each splits up into its constituents which traverse upward along the margins in the adjacent corolla lobes. Generally the two marginal bundles in a corolla lobe unite to form an arch in its apex (Fig. 17). In some instances, weakly developed dorsal bundles are seen as isolated stretches along the midribs of the petals (Fig. 19) and in still lesser number of cases, the dorsal bundles are fully developed (Fig. 18). The style is terminal, terete with a swollen nectar disc at its base and is tipped by a long, somewhat swollen, bifid stigmatic lobe (Figs. 49-50). The androecium comprises 5, epipetalous stamens. The anthers are laterally connate to form a tube around the style and each is tipped by a flat, membranous appendage.

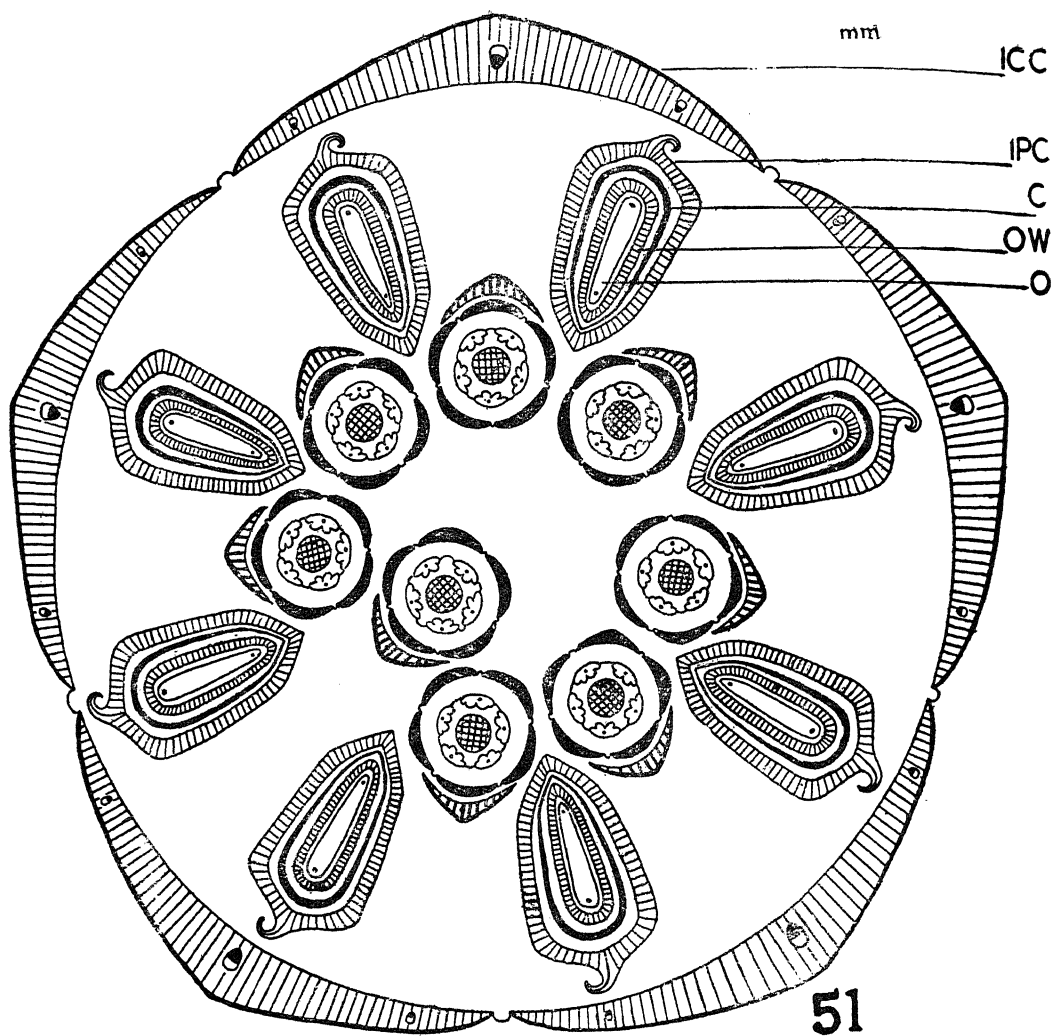












## EXPLANATION OF FIGURES

Figs. 1-21. *Acanthospermum hispidum*. Fig. 1. A young plant showing the root system and scars of the first five pairs of fallen leaves (portion of the left hand side after the first branching not shown). About 1/4 of natural size. Fig. 2. Shows a trichome from the leaf. X95. Fig. 3. Shows a trichome from the peduncle of the compound capitulum. X95. Figs. 4-5. Show young and old trichomes from the ovary wall of the male florets of the compound capitulum. X95. Figs. 6-8. Show some developmental stages of the glandular trichomes occurring on the outer surface of the involucre of the peripheral, capitula, corolla and the paleae. X95. Fig. 9 Shows a compound capitulum terminating the apex of the main shoot and portions of branches from the axils of the pair of leaves below. X3. Fig. 10. Shows a peripheral capitulum in side view. X4. Fig. 11. Same as the preceding; the involucre has been cut longitudinally on the two sides and separated apart to expose the ovary part of the contained floret. X4. Fig. 12. Shows the longitudinal section of a spine from the outer surface of the involucre of a peripheral capitulum. X120. Figs. 13-14. Show cleared corollas of the female ligulate florets of the peripheral capitula with the tube cut open longitudinally on the posterior side and spread open to show variation in vasculature. X10. Fig. 15. Shows a male floret of the central capitulum. X7. Fig. 16. Shows a palea of the male floret of the central capitulum X7. Figs. 17-19. Show cleared corollas of the tubular florets of the central capitulum, cut longitudinally on one side and spread open to show the variation in their vasculature. X10. Figs. 20-21. Show serial transverse sections of the stem in the nodal region showing the trilacunar, 3-traced node. X15. Explanation of lettering: ICC = Involucre of compound capitulum; IPC = Involucre of peripheral capitulum; OW = ovary wall; V = Marginal bundle of the petals; VV = Compound marginal bundle of the petals.

Figs. 22-49. *Acanthospermum hispidum*. Figs. 22-25. Serial transverse sections of a compound capitulum from below upward showing the origin of vascular traces to the involucre bracts, peripheral capitula and the central capitulum of male florets (for explanation, see text). Figs. 26-40. Serial transverse sections of a peripheral capitulum from below upward showing the vascularization of its various parts (for explanation, see text). Figs. 41-49. Serial transverse sections of a male floret of the central capitulum from below upward showing the origin of the vascular traces to its palea and other parts (for explanation, see text). Explanation for lettering: C = Corolla; D = Dorsal bundle of the carpel; ICC = Involucre of compound capitulum; IPC = Involucre of peripheral capitulum; O = Ovule; O.W. = Ovary wall; OT = Ovular trace; P = Palea of the male florets of the central capitulum; VV = Compound marginal bundle of the carpels.

Figs. 50-51. *Acanthospermum hispidum*. Fig. 50. Shows a diagrammatic representation of the vascular skeleton of a compound capitulum in its median longitudinal section (for explanation, see text). Fig. 51. Shows the ground plan of the compound capitulum. Explanation of lettering as before.

## Vascular Anatomy :

*Node.*—The stele of the stem consists of a ring of about 20, conjoint-collateral, endarch vascular bundles. Three traces, each from a separate gap in the stem stele on either side diverge out and enter the base of the leaf of the respective side (Figs. 20–21). The node is, therefore, of the trilacunar, 3-traced type. Two vascular traces on either side of the median leaf trace from the same gap in the stem stele begin to divide *in situ* and form the stelar ring of the axillary shoot (Figs. 20–21).

*Compound Capitulum.*—The compound capitulum is shortly stalked. Its stelar ring comprises about 10, conjoint-collateral vascular bundles (Figs. 21–22). During the upward course, the vascular bundles increase in number by radial divisions. Three traces, each from a separate gap in this receptacular stele diverge outward for each of the five bracts of the compound capitulum (Fig. 23). Inside the bract itself, the three main bundles give out lateral branches. Two vascular traces from a gap in the receptacular stele unite together during the outward course to form a single trace for each of the peripheral capitula (Fig. 24). The remaining strands of the receptacular stele are used up in supplying the male florets of the central capitulum. A single vascular strand going to each floret splits up tangentially into an outer trace for its palea and an inner for the floret proper (Figs. 25, 41–43, 50).

*Peripheral Capitula.*—As earlier stated, a single vascular strand formed by the union of two traces enters into the base of each of the peripheral capitula (Fig. 26). Here it gives out three vascular traces on the posterior and three on the anterior side (Fig. 27). These recede outward and excepting the median member of each side, the remaining bundles divide tangentially to form the inner four bundles around a central bundle and the outer four bundles (Figs. 28–31). Two of the latter and a median bundle on the posterior as well as on the anterior side form the six vascular traces of the involucre. Inside the involucre itself, these bundles further split up and supply a trace each to most of the spines on its outer surface. The bundles of the spines generally terminate in their basal part or at a slightly higher level (Fig. 12). The median bundles on the posterior and anterior sides furnish the vascular supply of the apical horns of the respective sides (Figs. 23–25, 33–34, 50).

The central vascular strand along with the four vascular strands around it enter into the base of the floret (Figs. 29–32). Here the former bundle (VV) which is interpreted as a compound marginal bundle of the two carpels puts out a strong lateral trace (OT) on the anterior side for the ovule and then terminates blindly. The ovular trace traverses outward, downward and then upward to enter the funiculus of the ovule (Figs. 31–33). As a result of this arched course, it is cut at two places in transverse sections at the lower levels (Figs. 31–32). The ovular bundle ascends upward in the raphe up to the chalaza, then descends downward in the integument on the opposite side and terminates only a little before the micropyle (Fig. 50). The four peripheral bundles continue upward in the ovary wall (Figs. 33–36). These are obviously compound bundles. In the top of the ovary, a posterior, and diagonally opposite to it, an anterior bundle tangentially split up to separate off the two carpellary dorsal bundles which furnish the style. These traverse horizontally inward and then upward in the style and terminate in the top of the stigmatic lobes (Figs. 37–40).

After furnishing the vascular supply of the style, the four peripheral bundles continue the upward course in the short corolla tube (Fig. 38). No vascular traces

are given off to the basal nectar-disc. A little below the posterior sinus of the ligule, one of the posterior bundles radially divides into two (Figs. 39) followed by the splitting of the corolla tube in between these bundles to form the ligule (Fig. 40). All these five bundles continue into the ligule and terminate at various distances along its length (Fig. 13). In some instances, none of the four bundles seen in the corolla tube divides so that only these four bundles are seen in the ligule (Fig. 14).

**Central Capitulum** :—After furnishing the vascular supply to the peripheral capitula, the receptacular stele breaks up into as many vascular strands as the number of florets in the central capitulum (Fig. 25). The single vascular trace going to a floret divides tangentially into an outer trace for its palea and an inner for the floret proper (Figs. 25, 41-43). The single vascular bundle in the base of the ovary-like portion of the floret gives out five branches and then terminates blindly (Figs. 43-44). These five bundles which are compound traverse upward in the peripheral part of the pistillode. In its top, the posterior and one of the two anterior bundles tangentially split up to separate off the two carpellary dorsals on their inside. These traverse inward and then upward in the style and terminate near the top of the stigma (Figs. 46-50). The outer five bundles which are still compound continue their upward course in the corolla tube for a short distance and then tangentially split up to form the inner five staminal traces and the outer five compound marginal bundles of the petals (Fig. 47). The former enter the stamens and terminate near the upper level of the another loculi and do not continue onward into the apical appendages. The compound marginal bundles of the petals radially split up into their constituents below the sinuses of the corolla lobes and the two marginal bundles in a petal lobe generally unite in its apex to form an arch or only come close to each other without uniting (Figs. 17-19).

#### Discussion :

In his book, "Features of evolution in the flowering plants", Good (1956) has given a list, compiled from several sources of the 46 genera of the family Compositae which possess compound capitula. To this list we would like to add the genus *Acanthospermum* under the tribe Heliantheae, in addition to *Lagasca* and *Goulierella* which are already known to possess compound capitula. Like *Lagasca*, *Elephantopus*, *Sphaeranthus* etc., but unlike *Echinops*, the compound capitulum of *Acanthospermum* is supported by an involucre of its own, inside which, there are 5 to 9 peripheral capitula, each enclosing a single female floret of the ligulate type and a central capitulum of about 7, paleaceous, tubular type of male florets (Figs. 9, 25, 50-51). The involucre of a peripheral capitulum completely invests the ovary portion of the contained female floret, leaving an apical opening through which the corolla and the style project out (Figs. 10-11, 50). It will be recalled that the vascular supply of this involucre consists of two arcs of three vascular traces each, one on the posterior and the other on the anterior side (Figs. 27-30). These supply a single trace each to most of the spines on the outer surface of the involucre. It can, therefore, be reasonably concluded that this involucre consists of a number of 1-traced bracts, all fused together around the ovary of the contained, solitary, female ligulate type of floret. In this structural features, the involucre of a peripheral capitulum of the compound capitulum of *Acanthospermum hispidum* is similar to that of a female capitulum in *Xanthium strumarium*. However, in the former, there is only one female floret with a ligulate corolla and in the latter there are two, apetalous, female florets inside the

involucre. In both these species, the two long, prominent horns at the top of the involucre represent the apices of the two of the upper bracts of the involucre. In *Caesulia axillaris* (Ramayya, 1962 ; Manilal, 1963) and *Flaveria repanda* (Manilal, 1963), however, the involucre of a constituent capitulum of the compound capitulum consists only of two medianly placed bracts. In *Flaveria repanda*, they are 3-traced but 1-traced in *Caesulia axillaris* ; in the former, both the bracts are more or less free and the anterior larger bracts laterally overlaps the posterior smaller one. In *Caesulia axillaris*, the two involucre bract in their basal part are united to form an investment around the ovary of the single floret contained inside but are free above where the anterior bract laterally overlaps the posterior one (cf. *Flaveria repanda*).

The central part of the compound capitulum, consisting of about 7, paleaceous, male florets of the tubular type should be considered as one capitulum, distinct from the peripheral, unifloral capitula. It has no involucre, unless, of course, the subtending bracts (paleae) are regarded as forming the involucre. Good (1956) states that "an involucre is apparently never totally absent in Compositae, or in other words there are no plants lacking an involucre which are otherwise characteristic of the family". The central capitulum of *Acanthospermum hispidum*, consisting exclusively of tubular type of male florets is comparable to the capitulum in the genus *Wilkesia* (Rendle, 1938) where also the involucre is regarded as absent and where the obvious structure looking like an involucre is really composed of the subtending floral bracts (paleae) of the outermost florets. We are of the opinion that all such capitula where even the outermost bracts have flowers in their axils be considered as non-involucrate.

In the family Compositae, the basic type of node is 3-lacunar with 3 traces<sup>s</sup> (Sinnott, 1914). In *Acanthospermum hispidum*, it conforms to this basic type. Solbrig (1961) who has studied the anatomy of the leaf and node of some Andean Compositae of the tribe Asteroideae reports the occurrence of a unilacunar node with a single trace "presumably by reduction" in eight species. More interesting is the fact that trilacunar and unilacunar nodes are reported for the different species of the same genera, viz., *Chiliotrichum*, *Parastrephia* and *Nardophyllum*. Recently, Manilal (1963), reported the occurrence of a trilacunar node in 63 Indian species of this family but a unilacunar node in *Brachycone assamica* and *Calendula officinalis*. Manilal (1963) also reports that in *Artemisia vulgaris*, the lower nodes are trilacunar with one trace.

The mode of vascularization of the ovule in the female floret of the peripheral capitula of the compound capitulum of *Acanthospermum hispidum* throws a flood of light on the nature of the basal ovule in this family. As will be recalled, the single vascular bundle in the base of a peripheral capitulum first furnishes the vascular supply to its involucre and the ovary wall of the contained floret (Figs. 26-30). It then continues a little upward in the base of the ovary and then supplies the ovular trace (OT) as a lateral branch on the anterior side and then terminates blindly (Figs. 31-32, 50). This bundle (VV) which supplies the ovular trace as a lateral branch is obviously the compound marginal bundle of the two carpels. It is, therefore, evident that the basal ovule of *Acanthospermum hispidum* is really borne laterally, obviously on a reduced axile placenta. Manilal (1963) reports similar mode of vascularization of the ovule in *Vernonia cinerea*, *Solidago odora*, *Verbesina crocata* and *Volutarella ramosa*. In *Cotula anthemoides* (Manilal, 1963), the compound marginal bundle of the carpels traverses straight upward for a short distance in the basal septum of the ovary and then sharply bends towards the funiculus. The portion of the vascular bundle beyond

the bend is interpreted as the ovular trace which is continuous with the compound marginal bundle of the carpels due to the suppression of the latter beyond the origin of the former from it as a lateral branch and the ovule is considered as laterally attached on the placenta. Murty (1952) who reported a similar behaviour of the vascular strand supplying the basal ovule in *Peperomia* regarded the basal position as having been derived from an ancestral parietal placenta. A similar course of the vascular bundle supplying the ovule was also reported in *Boehmeria cylindrica* by Bechtel (1921) and the basal position of the ovule was likewise interpreted as having been derived from a lateral one. On anatomical grounds, the basal ovule in the families Cyperaceae (Blaser, 1941 ; Snell, 1936), Santalaceae (Smith and Smith, 1942a, 1942b), Polygonaceae (Laubengayer, 1937) has been considered to have descended from axile or free central placentation. In certain other families, as in the Gramineae (Blaser, 1941), Ranunculaceae (Chute, 1930 ; Eames, 1931 ; Smith, 1926), Urticaceae (Bechtel, 1921), Platanaceae (Boothroyd, 1930) etc., the basal ovule has been considered to have been derived from parietal placentation. Sachs (1874) while discussing the origin of the inferior ovary mentioned that the ovule in *Helianthus annuus* is derived from a lateral position and is borne on an arrested placenta. While describing certain abnormalities in the ovary of *Senecio vulgaris*, Small (1916, 1919) mentions several cases of biovulate ovaries and that the ovules are lateral in position. Berkeley (1931) suggested that the basal ovule in *Helianthus decapetalus* might have been derived from an axile or free central placentation. According to Eames (1951), a really basal ovule in the majority of cases—perhaps in all cases arises from axile placentation. In view of the foregoing discussion, there cannot be any room for the views of Payer (1857) and others (see Puri, 1952) who consider the placenta as a stem structure.

#### Summary :

1. The present work deals with the morphology and vascular anatomy of the node and capitulum of *Acanthospermum hispidum*.

2. The main shoot, after producing 5-9 pairs of opposite-decussately arranged leaves terminates into a capitulum. Further growth is continued by the axillary buds of the uppermost pair of leaves ; each after producing a pair of leaves also terminates into a capitulum and this mode of growth is maintained throughout the life of the plant which thus becomes a dichasial cyme of capitula.

3. The capitulum is compound. It consists of 5 to 9 peripheral capitula, each containing a ligulate type of female floret and a central, non-involucrate capitulum of about 7, paleaceous, tubular type of male florets. The involucre of a peripheral capitulum is laterally flattened and obconic. It completely encloses the ovary part of the contained floret and has an apical opening through which its corolla and the style project out. The outer surface of the involucre is covered with numerous spines having recurved tips and glandular type of hairs. At the top of the involucre, there are two long, medianly placed horns, the posterior of which is more or less straight and shorter than the anterior one which is strongly reflexed. The ovary-like basal portion of the male florets of the central capitulum of the compound capitulum is almost solid, showing two small loculi in the upper part but no ovules. The compound capitulum is supported by an involucre of five, green, more or less leafy bracts which are slightly united in their basal region.

4. The node is of the trilacunar, three traced type.

5. The stele in the stalk of the compound capitulum consists of a ring of about ten, conjoint-collateral vascular bundles. Each of the five bracts of its involucre is three traced. Two traces from the receptacular stele are given off to each of the peripheral capitula. These unite to form a single strand in their outward course through the receptacular cortex so that a single vascular bundle is present in the base of a peripheral capitulum. The remaining vascular bundles of the receptacular stele are used up in supplying a single trace to each of the floret of the central capitulum.

6. The single vascular bundle present in the base of a peripheral capitulum gives off two arcs of three bundles each to its involucre, one on the posterior and the other on the anterior side. The lateral bundles of these arcs tangentially split up to supply four vascular traces on the inner side to the ovary wall. The central bundle which is now interpreted as the compound marginal bundle of the two carpels gives out the ovular trace as a lateral branch on the anterior side and then terminates blindly. The ovular bundle traverses upward in the raphe up to the chalaza, then descends down in the integument on the opposite side and terminates only a little before the micropyle.

7. The single vascular trace going to a floret of the central capitulum tangentially splits up into two strands, the outer for its palea and the inner for the floret proper. The latter gives out five branches and then terminates blindly. In the top of the ovary-like portion of the floret, a bundle on the posterior and another on the anterior side give off the vascular traces to the style. Then all the five peripheral bundles continue upward into the corolla tube for a short distance and tangentially split up into the inner five stamen traces and the outer five compound marginal bundles of the petals.

8. The basal ovule in the family Compositae is regarded as having descended from an original axile condition. The single basal ovule in *Acanthospermum hispidum* and in the majority of the species of the family Compositae belongs to the anterior locus of an original bilocular condition and its raphe is dorsal.

#### Acknowledgements :

It is a matter of great pleasure for us to record our deep sense of gratitude and heartfelt thanks to Professor S. B. Saksena for facilities and encouragement.

#### References :

- Bechtel, A. R. The floral anatomy of the Urticales. *American J. Bot.*, **8** : 383-410, 1921.
- Berkeley, C. J. A. Abnormalities in the ovaries of *Helianthus decapetalus*. *New Phyt.*, **30** : 42-55, 1931.
- Blaser, H. W. Studies in the morphology of Cyperaceae I. Morphology of the flowers A. Scirpoid genera. *American J. Bot.*, **28** : 542-551, 1941.
- Studies in the morphology of Cyperaceae I. Morphology of the flowers B. Rhynchosporoid genera. *American J. Bot.*, **28** : 832-838, 1941.
- Boothroyd, L. E. The morphology and anatomy of the inflorescence and flower of the Platanaceae. *American J. Bot.*, **17** : 678-693, 1930.
- Chute, H. M. The morphology and anatomy of the achene. *American J. Bot.*, **17** : 703-723, 1930.

- Eames, A. J. The vascular anatomy of the flower with refutation of the theory of carpel polymorphism. *American J. Bot.*, **18** : 147-188, 1931.
- Again—The new morphology. *New Phyt.*, **50** : 17-35, 1951.
- Gamble, J. S. *Flora of the Presidency of Madras*. Vol. II. Calcutta, 1921.
- Good, R. *Features of evolution in the flowering plants*. London, 1956.
- Laubengayer, R. A. Studies in the anatomy and morphology of the polygonaceous flower. *American J. Bot.*, **24** : 329-343, 1937.
- Manilal, K. S. Morphological studies in the family Compositae. *Ph.D. thesis, Univ. of Saugar, Saugar (M P.), India*, 1963.
- Murty, Y. S. Placentation in *Peperomia*. *Phytomorphology*, **2** : 132-134, 1952.
- \*Payer, J. B. *Traite d' Organogenie comparee de la fleur*. Paris, 1857.
- Puri, V. Placentation in angiosperms. *Bot. Rev.*, **18** : 603-651, 1952.
- Ramayya, N. On the capitulum of *Caesulia* Roxb. *Current Sci.*, **31** : 24-25, 1962.
- Rendle, A. B. *The classification of flowering plants*. Vol. II. *Dicotyledons*. Cambridge, 1938.
- Sachs, J. *Lehrbuch der Botanik*. 2 Aufl. Leipzig, 1874.
- Sinnott, E. W. Investigation on the phylogeny of angiosperms I. The anatomy of the node as an aid in the classification of angiosperms. *American J. Bot.*, **1** : 303-322, 1914.
- Small, J. Anomalies in the ovary of *Senecio vulgaris* L. *Ann. Bot.*, **30** : 191-192, 1916.
- The origin and development of the Compositae. *New Phyt.* Reprint No. 11, London, 1919.
- Smith, F. H. and Smith, E. C. Anatomy of the inferior ovary of *Darbya*. *American J. Bot.*, **29** : 464-471, 1942a.
- Floral anatomy of Santalaceae and related forms. *Oregon State Monogr. Stud. Bot. No. 5* : 1-93, 1942b.
- Smith, G. H. Vascular anatomy of Ranalian flowers I. Ranunculaceae. *Bot. Gaz.*, **82** : 1-29, 1926.
- Snell, R. S. Anatomy of the spikelets and flowers of *Carex*, *Kobresia* and *Uncinia*. *Bull. Torrey Bot. Club*, **63** : 277-295, 1936.
- Solbrig, O. T. Leaf and nodal anatomy of some Andean Compositae—Asteraceae. *J. Arnold Arb.*, **42** : 276-294, 1961.
- Willis, J. C. *A dictionary of flowering plants and ferns*. 6th Ed. Cambridge, 1931.

A NEW SPECIES (*SCHWARTZITREMA DUMBELI* SP. NOV.)  
OF TREMATODE (DIGENEA) FROM THE INTESTINE OF SNAKE  
DARTER, *ANHINGA MELANOGASTER* FROM INDIA

By

ONKAR NATH and A. N. GUPTA

K. N. Government College, Gyanpur (Varanasi), India

[Received on 17th February, 1964]

Three specimens of this parasite were collected from the intestine of two snake darters, *Anhinga melanogaster* (Pennant) shot on two occasions in the suburbs of Gyanpur. The living worms were creamish white in colour and show slight movements of their body.

The body is large and is clearly divided into two parts. The fore-body, measuring 1.230 mm. long and 0.930 mm. broad in the acetabular region, has the outline of a balloon. With its ventral wall reaching only slightly in front of the acetabulum, it appears marsupiform. Thus, while the posterior funnel shaped portion of the fore-body is composed of both dorsal and ventral walls, its anterior portion is merely a forward prolongation of the dorsal wall. A more or less distinct neck region, measuring  $0.105 \times 0.165$  mm. separates the fore-body from the hind-body. Besides the disparity in the width of the posterior part of the fore-body and that of the neck region, a slight constriction at the junction of the two demarcates the neck region. The hind-body is more or less like a long sac whose posterior region broader than the anterior. It measures 1.0830 mm. in length and 0.870 mm. in maximum breadth.

The suckers are well developed. The oral sucker is terminal and globular, measuring  $0.120 \times 0.150$  mm. It projects out of a shallow depression at the anterior end. The ventral sucker, situated more or less in the middle of the fore-body lies 0.555 mm. away from the anterior end. Measuring  $0.182 \times 0.210$  mm. across, it is cup-shaped. A pair of large protractile lobes arises from the dorsal wall of the cavity of fore-body. They project out beyond the margin of the latter on either side of oral sucker. These lobes measuring  $0.240 \times 0.360$  mm. are larger than the oral and ventral suckers, and are joined by a transverse band. The protrusible hold fast organ consists of a large funnel-shaped main lobe with notched margin and a pair of accessory lobes situated ventrolaterally to it.

The mouth leads through a short prepharynx into a small muscular pharynx more or less rounded in shape and measuring  $0.075 \times 0.090$  mm. The pharynx is followed by a short oesophagus 0.180 mm. long which bifurcates into intestinal caeca at a distance of 0.150 mm. in front of the acetabulum and of 0.180 mm. behind the anterior end. The two caeca, diverging on either side of the acetabulum run into the hind-body.

The reproductive organs lie in the posterior two third of the hind-body. The testes, are tandem and postovarian. The anterior testis lying mostly to the left is roughly triangular in shape and measures  $0.300 \times 0.375$  mm. The dumbel-shaped posterior testis is situated just behind it, occupying the entire width of the hind-body in that region. It measures  $0.225 \times 0.75$  mm. The saccular vesicula seminalis lies just behind it and continues into a short ejaculatory duct which meets the terminal part of the uterus inside the genital cone.

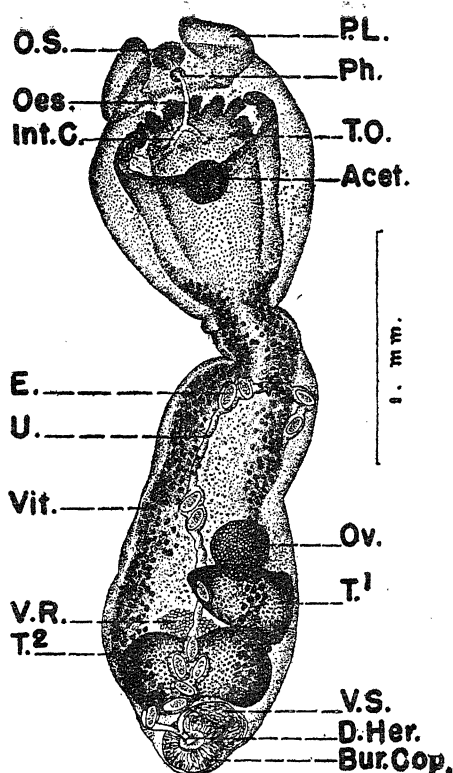


Fig. 1. *Schwartzitrema dumbeli* ; Entire ventral view.

#### KEY TO LETTERING

Acet	... Acetabulum	P. L.	... Protractile lobe
Bur. Cop.	... Bursa copulatrix	Ph.	... Pharynx
D. Her.	... Ductus hermaphroditicus	T1.	... Anterior testis
E.	... Egg	T2.	... Posterior testis
Int. C.	... Intestinal caeca	T. O.	... Tribocytic organ
O. S.	... Oral sucker	U.	... Uterus
Oes.	... Oesophagus	V. S.	... Vesicula seminalis
OV.	... Ovary	Vit.	... Vitellaria

The small, sub-globular and pretesticular ovary is situated on the left side just in front of the anterior testis partly overlapping it. It measures  $0.180 \times 0.195$  mm. The vitelline reservoir and shell gland complex are intertesticular and are mostly masked by the two testes. The uterus, running a short distance in front of the ovary turns backwards to run straight up to the hind end. It enters the genital cone and joins the terminal part of the ejaculatory duct to form a short common duct, which opens at the tip of the genital cone. The latter lies within a small copulatory bursa which opens to the exterior through a wide and terminal opening at the hind end. The ova are yellow in colour and few in number, about a dozen. Oval in shape, they measure  $0.075-0.105$  mm.

Small vitelline follicles extend from the neck region upto the region of copulatory bursa in the hind-body. Anteriorly they extend slightly into the fore-body

as well. The neck region is full of vitellaria. The latter continue in the hind-body close to its right margin for most of its length. On the left side the vitelline follicles are more widely separated from the body margin.

Host .. *Anhinga melanogaster* (Pennant)

Location .. Intestine

Locality .. Gyanpur (Varanasi)

#### Discussion :

Only two species have so far been reported under the genus *Schwartzitrema* Perez Vigueras, 1941. One is the genotype *S. schwartzi* (Perez Vigueras, 1940) Perez Vigueras, 1941 and other is *S. seamasteri* Chandler, 1951. The present species can clearly be distinguished from the genotype, primarily by the shape and size of its body. The genotype has a smaller size and a relatively long and slender neck. The new species is further separated by the dumbel-like shape of its posterior testis and by the smaller size of its eggs, which are much smaller than its ovary. It differs from *S. seamasteri* in a number of characters. The absence of a prepharynx in it, the more forward extension of its vitellaria so as to enter the fore-body, the larger size of its body having different shape and the smaller size of its eggs, are some of the important characters which separate it from *S. seamasteri*. Evidently the present form appears to be a new species for which the name *Schwartzitrema dumbeli* is proposed.

#### References :

- Chandler, A. C. Trematodes from the man-o-war bird, *Fregata magnificens rothschildi*, on the Texas coast, with the description of a new species, *Schwartzitrema Seamasteri*, *Texas J. Sci.*, **3** (2) : 186-189, 1961.
- Perez Vigueras, I. *Schwartzitrema* n.n. para *Schwartziella* Vigueras, 1940 (Trematoda, Strigeidae) nec *Schwartziella* Leroux 1936. *Mem. Soc. Cubana Hist. nat.*, **15** : 263, 1941.
- Yamaguti, S. *Systema helminthum* Vol. I. Digentic trematodes of vertebrates Part I, II, 1958.

# KARYOTYPE OF *CHRYSANTHEMUM CINERARIAEFOLIUM* VIS.

By

M. L. H. KOUL\*

Regional Research Laboratory, Jammu

[Received on 27th November, 1963]

*Chrysanthemum cinerariaefolium* is a perennial plant and is known for its insecticidal properties. The insect powder known as Pyrethrum is produced from the dried flowers of *C. cinerariaefolium*. Pyrethrum preparations occupy an important place in anti-malarial measures and afford protection against a number of Horticultural and Agricultural pests. It is effective as an external application in pediculosis and scabies, also useful as an anthelmintic against *Ascaris linata* and other internal parasites in veterinary practices. Keeping in view its medicinal utility it becomes important to improve the quality and quantity of active constituents of the plant. A cytogenetical investigation in its improvement has been taken up in this Laboratory by the author and for this purpose, a study of karyotype is necessary primarily.

## Materials and Methods :

The seeds of the plant under investigation were obtained from Barzulla Farm, Srinagar. For root tips, the seeds were germinated in petridishes. Somatic chromosomal studies were made from permanent preparations. The root tips were heated in 2 per cent Aceto-orcein and N.HCl (9 : 1) for a few seconds and kept in the stain for half an hour. They were then squashed in 1 per cent Aceto-orcein solution. For meiotic studies flower buds were fixed in 1 : 3 Acetic-alcohol and stained in Aceto-carmine.

## Observations :

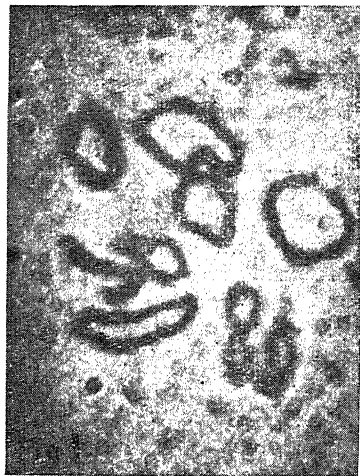
Meiosis was normal with the formation of nine bivalents at diakinesis and metaphase Ist. The nine bivalents were of ring and rod type (Fig. 1 and 2). Chromosomes in most of the Pollen mother cells separated normally to both poles at anaphase Ist. In exceedingly few Pollen mother cells one or two lagging chromosomes were observed. However, no micronucleus was seen in the cells at telophase I and II. All the tetrads observed were without micronucleus or microcyte. One bivalent was attached to nucleolus at diakinesis which was V shaped and was attached with nucleolus at the terminal position of both arms. A satellite was found on the arm of the homologous chromosomes of the bivalent. This bivalent is identified as chromosomes No. 7 on the bases of karyotypic study.

For karyotypic studies metaphase plates were studied of many root tip cells. The lengths of the chromosomes of each cell were arranged in a series of increasing magnitude. The average length of each chromosome size was calculated. It is realised that chromosome size variation may be due to such environmental factors, as the growing condition of the plant, exact stage of mitosis (early or late metaphase), in each cell studied variation in the air, temperature and in the nature and duration of prefixation. Comparisons of the various pretreatments

---

\*Botany Department, Banaras Hindu University, Varanasi—5.

were therefore made to decide whether these results were sufficiently consistent to warrant dependance on them. Cold shocks, 8 -OH - Quinoline, coumarine and colchicine as pretreating agents were tried, but most satisfactory results were obtained with colchicine.



Photomicrograph of late Diplotene State ( $n=9$ ) Magnification X2100.

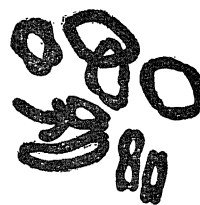


Fig. 2

(Camera-lucida) Drawing of the fig. 1.



Photomicrograph of Somatic metaphase ( $2n=18$ ) Magnification X2100.

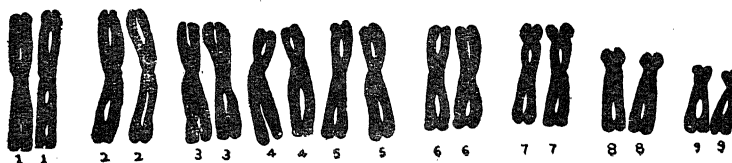


Fig. 4

Somatic Chromosomes *Chrysanthemum-cinerariaefolium* vis. ( $2n=18$ ) Magnification X3800.

Reliability of the measurements was evaluated by consideration of variation which exists between chromosomes from cell to cell and plant to plant. It was found that within any one plant the variation between each of the series of measurements for corresponding size ranges of chromosome was usually not more than  $2\mu$  and at the most  $3\mu$ . It is therefore felt that much reliance can be placed on the measurement obtained.

The somatic number as reported by Dowrick (1952) is  $2n=18$  and author found at diakinesis 9 bivalents. The nine pairs of chromosome get classified into three types. 3 pairs of chromosomes with median centromere, 4 pairs with submedian and 2 pairs with subterminal centromere. The morphology of the nine pairs of chromosomes are as follows. (Terminology after Battaglia, 1955).

Chromosome No. 1 is the longest chromosome and possesses a median centromere. It has twice the length of the shortest chromosome of the complement.

Chromosome No. 2 is the second longest chromosome with median centromere.

Chromosome No. 3 and 4 are median length chromosomes with a distinct submedian centromere.

Chromosome No. 5 has a submedian centromere.

Chromosome No. 6 has a median centromere with isobrachial arms.

Chromosome No. 7 has submedian centromere and the only satellited chromosome.

Chromosome No. 8 is the second to the shortest chromosome with a subterminal centromere.

Chromosome No. 9 is the shortest in the complement with a subterminal centromere.

### Discussion :

No chromosome with terminal centromere has been found. Corsi (1962) reports three satellited chromosome viz., chromosome No. 7, 8 and 9 but the present author in the investigated material could find only one satellited chromosome. *C. lineare* ( $2n=18$ ) according to Tanaka and Shimotomai (1961) has chromosomes with median and submedian centromere and no chromosome with subterminal or terminal centromere. *C. vulgare*, *C. rupestre* and *C. nipponicum* ( $2n=18$ ), all diploid as reported by the above authors possess two pairs of chromosomes with subterminal centromere like that of *C. cinerariaefolium*. So on the basis of position of centromere *C. lineare* appears to be most primitive. *C. lineare*, *C. cinerariaefolium* and *C. nipponicum* have 3 median, 4 submedian and 2 subterminal chromosomes, while *C. rupestre* has advanced further in having only 2 median, 5 submedian and 2 subterminal chromosomes. So at the diploid level chromosomes of *C. rupestre* appear to be advanced than the other four investigated diploid species in karyotypic considerations. The length variation of the chromosomes of the species are as follows :

*C. lineare* ..  $16\mu-12\mu$  ; *C. cinerariaefolium* ..  $12\mu-6\mu$  ;

*C. vulgare* ..  $8\mu-5\mu$  ; *C. nipponicum* ..  $7\mu-4\mu$  ; *C. rupestre* ..  $6\mu-4\mu$ .

The smallest chromosome length is in *C. rupestre* ( $6\mu-4\mu$ ) favours the view that it represents the most advanced species among the investigated ones.

Difference in satellite chromosomes also may provide an additional light on the evolutionary trends. Tanaka (1959) found a decrease in satellite chromosomes of *C. boreale* following its speciation. He also found that *C. makinoi* which is considered to be an advanced species, had two pairs satellite chromosome (Tanaka 1959b). In these two species the satellite of chromosomes 7 have disappeared. Similar disappearance of satellite has occurred in *C. rupestre* and *C. nipponicum* (Tanaka and Shimotomai, 1961). In *C. nipponicum*, satellite of another chromosome (No. 4) has been lost, so that chromosome No. 8 is the only satellited one, while in *C. cinerariaefolium* similar loss of satellites has occurred and it is the chromosomes 7 that is only satellited.

The disappearance of satellites resulted in a loss of nucleolus organising capacity. In *C. lineare* and *C. vulgare* which possess three satellited chromosome pairs, three bivalents in meiosis are nucleolar, in *C. rupestre* in which two chromosome pairs are satellited, two bivalents are nucleolar, while in *C. cinerariaefolium* and *C. nipponicum* only one bivalent is nucleolar. So only one paired chromosome is satellited. Thus the loss of satellite resulting in a consequent decrease of nucleolar chromosomes may be partially responsible for the evolution and speciation of chrysanthemums at diploid level.

#### Summary :

The author has studied the meiotic and mitotic behaviour of the chromosomes of *Chrysanthemum cinerariaefolium*. On the basis of mitotic chromosomes a karyotype has been studied and only one chromosome is satellited. The karyotype is symmetrical.

#### Acknowledgements :

The author is highly thankful to Dr. E. K. Janaki Ammal and to Prof. R. Misra, for the valuable guidance and helpful suggestions. My thanks are due to Dr. I. C. Chopra, Director, R. R. L., Jammu for providing the laboratory facilities and to C. S. I. R. for the award of a Senior Research Fellowship.

#### References :

- Battaglia, E. Chromosome morphology and Terminology. *Caryologia*, **8** : 179-187, 1955.
- Chopra, R. N., Nayer, S. L. and Chopra, I. C. Glossary of Indian medicinal plants, Council of Scientific and Industrial Research, 1956.
- Corsi, G. Contributo Alla Carriologia Di Chrysanthemum—Cinerariaefolium vis. *Caryologia* **15** (1) : 1962.
- Dowrick, G. J. Chromosomes of Chrysanthemum. *Heridity*, **6**, 3 : 365-75, 1952b.
- \*Tanaka, R. On the speciation and karyotype in Diploid and Tetraploid species of Chrysanthemum. I. C. Boreale ( $2n=18$ ) Jr. *Hiroshima Univ Series. B. Div. 2*, Vol. 9., 1959a.
- *Ibid.*, II C. Makinoi  $2n=18$  *Ibid.*, 1959b.
- and Shimotomai, N. Karyotype in 4 diploid species of chrysanthemum. *Cytologia*, **26**, 3-4 : 300, 1961.

---

\*Not seen in original.

# ON THE DEVELOPMENT OF RIGHT OVARIES IN CERTAIN BIRDS

By

K. G. BOSE and P. N. MEHROTRA

University Department of Zoology, Ranchi University, Ranchi

[Received on 22nd July, 1961]

## Introduction :

The right ovary and the corresponding oviduct are greatly reduced and generally absent in most of the birds. Many theories have been advanced in an attempt to explain the asymmetry of the right ovary in birds. During our studies on the sexual cycle of the Finch-lark, *Eremopteryx grisea*, we observed a few specimens with paired ovaries. The present paper gives an account of the functional development of right ovary in this bird.

## Material and Methods :

Out of nearly 150 birds dissected during the different months of the year for the study of the sexual cycle, six of them showed the presence of paired ovaries. The ovaries were fixed in Bouin's fluid, sectioned 5-7 $\mu$  thick and stained with Delafield's haematoxylin and eosin or Mann's methyl blue and eosin for histological study.

## Observations :

Equally developed, normal and histologically similar paired ovaries are occasionally present in the Finch-lark, though only the left oviduct is present and the right oviduct is invariably absent (Figure 1). The oocytes of the right ovary surrounded by their follicular layers are similar in structure to those of the left ovary. From the structure of the right ovary, it is evident that it is capable of developing to a fully mature condition.

## Discussion :

The present investigation shows that in *Eremopteryx grisea*, the right ovary occasionally develops to a functional state while the corresponding oviduct is always absent. Obviously, the ova from the right ovary must be passing out through the left oviduct. Occasional presence of right ovary has been reported in the fowls by Chappelier (1914), Macklin (1923), Domm (1927), Brode (1928) and McKenry (1931); in the pigeons by Riddle (1925); in the domestic ducks, *Anas boschas* by Chappelier (1914); in the English sparrow by Witschi (1935) and in the falcons by Gunn (1912) and Stieve (1918). Paired oviducts have been described by Chappelier (1914) in the domestic ducks and by Mckenry (1931) in a fowl. Presence of symmetrical and evenly developed paired ovaries in all the specimens of hawks—*Accipiter velox* and *Accipiter nisus* has been reported by Snyder (1931) and Stanley (1937).

The general absence of right ovary in birds has been explained in many ways. Gunn (1912) and Chappelier (1914) have suggested that the free progress of

growth of both the ovaries in the birds is prevented due to lack of room in the body cavity. Firket (1914) believes that the left ovary exerts a mechanical pressure on the right one and prevents it from developing further: that the left ovary takes the elements necessary for growth more rapidly than the right and consequently the latter is starved into suppression. Swift (1914) holds that an early asymmetry in the distribution of germ cells to the two sides of the chick embryo is responsible for the increased growth of the left ovary. Stieve (1918) suggests that the right lobe of the liver pushes dorsally in its growth and thus stops the right ovary from further development.

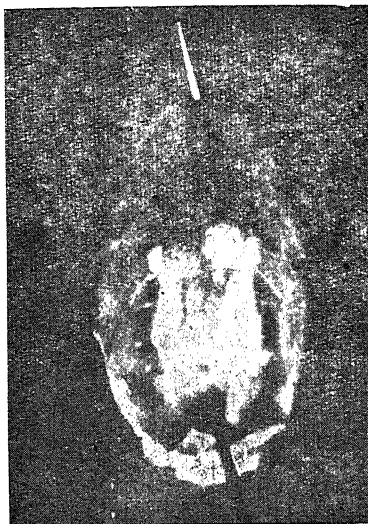


Fig. 1.

Witschi (1935) accounts for the unequal migration of germ cells by assuming a deficiency in the inductor strength of the right cortex. According to him the primordial germ cells are attracted across the forming mesentery by the stronger left side. Stanley (1937) has explained the disappearance of the right oviduct by assuming that the right gonadal deficiency shows its first effect upon the oviduct. According to him the hawks represent a stage of evolution showing that an even balance exists between the two gonad primordia in the hawks and hence little, if any, migration occurs across the mesentery from the right to the left thus leading to the development of both the ovaries.

The authors cannot subscribe to the view of Gadow (1912) that the right oviduct in the birds disappeared because of the failure of the corresponding ovary to produce the ova. The eggs of birds mature one by one at intervals of a full day or more and are laid singly. One oviduct is sufficient to take care of the delivery of the eggs produced in the ovary, be it paired or single.

In *Eremopteryx grisea*, which has normally only the left ovary there must be existing an inherent deficiency in the right gonad rudiment which leads to the uneven distribution of germ cells to the two sides. It appears that due to some unknown reasons, this uneven balance between the two gonad primordia is

disturbed in certain specimens and this leads to the development of the right ovary though the corresponding oviduct remains undeveloped.

#### Summary :

(1) Right ovary is occasionally present in the female reproductive system of *Eremopteryx grisea* and is capable of developing to a functional state.

(2) The right oviduct is invariably absent. The left oviduct is sufficient to take care of the delivery of the eggs produced in both the ovaries. The ova produced in the right ovary are obviously laid out through the left oviduct.

(3) The occasional presence of right ovary in some birds is due to an abnormality in their embryonic development whereby the uneven balance existing between the two gonad primordia is disturbed, resulting in an equal distribution of germ cells to the two sides. This leads to the development of the right ovary though the corresponding oviduct always remains absent.

#### References :

- Brode, M. D. Significance of asymmetry of the ovaries of the fowl. *J. Morph. and Physiol.*, **46** : 1, 1928.
- Chappelier, A. Persistence et developement des organes genitaux droits chez les femelles adultes des oiseaux. *Bull. Scient. de la France et de la Belg.* **47** : 361, 1914.
- Dommm, L. V. New experiments on ovariectomy and the problem of sex inversion in the fowl. *J. exp. Biol.*, **48** : 31, 1927.
- Firket, J. Recherches sur l'organogenese des glandes sexuelles chez les oiseaux. *Arch. de Biol.*, **29** : 201, 1914.
- Gadow, H. The one sided reduction of the ovaries and oviducts in the Amniota with remarks on mammalian evolution. *Proc. zool. Soc. London* **82** : 808, 1912.
- Gray, J. C. The development, histology and endocrine function of the compensatory right gonad of the hen. *Amer. J. Anat.*, **46** : 217, 1930.
- Gunn, T. E. On the presence of two ovaries in certain British birds, more specially the Falconidae. *Proc. zool. Soc. London*, **82** : 63, 1912.
- Macklin, M. T. A description of material from a gynandromorph fowl. *J. exp. Zool.*, **38** : 355, 1923.
- McKeny, F. D. A persistent right oviduct in the domestic fowl. *Anat. Rec.*, **49** : 51, 1931.
- Riddle, O. On the sexuality of the right ovary in the birds. *Anat. Rec.*, **30** : 365, 1925.
- Snyder, L. L. Paired ovaries in the hawks. *Auk*, **48** : 117, 1931.
- Stanley, A. J. Sexual dimorphism in the North American hawks, I. Sex organs. *J. Morph.*, **61** : 321, 1937.
- Stieve, H. Beobachtungen uber den rechten eierstock und rechten Legdarm des Huhnerhabichts (*Falcon palumbarinus*). *Morph. Jahr.*, *Leipzig*, **54** : 137, 1918.
- Swift, C. H. Origin and early history of primordial germ cells in the chick. *Amer. J. Anat.*, **15** : 483, 1914.
- Witschi, E. Origin of asymmetry in the reproductive system of birds. *Amer. J. Anat.*, **56** : 119, 1935.

# ON THE FUNCTIONAL MATURATION OF SPERMS IN THE EPIDIDYMIS OF BIRDS

By

P. N. MEHROTRA

University Department of Zoology, Ranchi University, Ranchi

[Received on 5th October, 1962]

## Introduction :

Our knowledge regarding the nature of changes undergone by the spermatozoa during their passage through the epididymis of birds is scanty. In fact very little is known about the functional significance of the avian epididymis though much experimental work on this problem has been done in the mammals, yielding results which are both numerous and varied.

The present paper gives an account of the role of the epididymis in the attainment of physiological perfection by the spermatozoa of *Anser melanotus*, *Saxicoloides fulicata* and *Copsychus saularis*. The epididymal tubules of these birds elaborate a secretion during the onset of reproductive period, which is poured forth in the tubule lumina. Witschi (1945) on the other hand has denied any secretory activity in the epididymis of *Passer domesticus*.

## Material and Methods :

The epididymis along with a portion of the testis was fixed in warm Bouin's or Zenker's fluid, sectioned 5-7 $\mu$  thick and stained either in Mann's methyl blue and eosin or in Delafield's haematoxylin and counterstained with eosin or aniline safranin. To determine the power of motility of sperms when in the testis tubules or in the epididymis, they were examined in physiological saline. Similar experiments were made with the sperms of *Copsychus saularis*, *Anser melanotus* and *Saxicoloides fulicata*.

## Observations :

The epididymal tubules of *Anser melanotus* are a series of contorted tubules which are connected with the efferent duct on the one hand and on the other they finally collect into a single duct, the vas deferens which meanders its way to open into the cloaca. These tubules rest on a basement membrane surrounded by a mass of fibrous connective tissue. The epididymal tubules are lined with columnar ciliated cells. The nuclei of the columnar cells are elongated and lie at different levels.

During the progressive phase of the testis cycle and just before the onset of reproductive period in *Anser melanotus*, in the months of December and January, the epithelial cells of the epididymal tubules hypertrophy. At certain places the cells grow more actively than at others and this leads to the formation of villi in the tubule wall. The cells become secretory. The secretory activity of the cells of the epididymal tubules is exhibited by the presence of numerous secretory granules and vacuoles in their cytoplasm. (Figure 1).

The secretion of the epididymal epithelium is poured forth in the tubule lumina. The stereocilia of the epithelial cells probably assist in forming the pathway for the secreted droplets. The lumina of some of the epididymal tubules can even be seen full of secreted lipoidal droplets. Similar observations have been made by me in the epididymis of *Saxicoloides fulicata* and *Copsychus saularis*. The epididymis of these birds also shows secretory activity just before the onset of their respective reproductive periods.



Fig. 1.

An examination of spermatozoa taken from the epididymis of *Anser melanotus*, *Copsychus saularis*, *Saxicoloides fulicata*, *Bubulcus ibis* in physiological saline revealed that they possessed a capacity of independent movement. Similar experiments were made with the spermatozoa of the above birds taken from the testis tubules and it was observed that these did not exhibit any capacity for movement at all. Thus obviously the spermatozoa acquire the independent capacity of motility only when they are in the epididymis and not during their stay in the testis tubules.

#### Discussion :

As observed by me during the progressive phase of the testis cycle and just before the onset of reproductive season, the epithelial cells of the epididymal tubules of birds show secretory activity and the tubule lumina can be seen full of secreted droplets. Thus my observations do not agree with those of Witschi (1945) who has denied any secretory activity in the epididymis of *Passer domesticus*. The secretory activity of the epididymis has also been reported by Young (1929a, 1929b and 1931) and many others in mammals.

My observations clearly show that the spermatozoa of *Anser melanotus*, *Copsychus saularis*, *Saxicoloides fulicata*, *Bubulcus ibis* acquire the capacity of independent movement only after their stay in the epididymis and lack this attribute when they are in the seminiferous tubules of the testis. The only experiments to my knowledge on the motility of avian spermatozoa are by Munro (1935) who has stated that the sperms of fowl taken from the testis tubules show only slight

motility, basic minimum possible by reason of energy reserves within the sperm. The observations on the motility of sperms are important because it has been shown by Bishop and Hancock (1955) that fertility of spermatozoa is intimately correlated with their motility. Tourande and Delcarte (1913), Redenz (1925 and 1926) and Young (1926a, b and 1931) have reported that sperms of rat taken from the caput epididymis showed less motility than those from the cauda epididymis. White (1932), Rao and Berry (1949 and 1950) also believed that the capacity of motility of spermatozoa is low in the testis and highest in the tail of epididymis. It has also been suggested by Young (1929a and 1931) and Munro (1935, 1938a and 1938b) that the spermatozoa from the testis are generally sterile.

It is generally believed that the spermatozoa are nearly immotile while within the reproductive tract and the motility which they exhibit when removed from the reproductive tract is due to increased availability of oxygen which acts as the principal activating agent or exogenous source of energy. Simeone (1933), Hartman (1939), Gunn (1936), Walton (1956) and Bishop and Mathews (1952) also believe that when removed from the reproductive tract and examined on slide, the sperms become motile due to aeration. Bishop (1962) believes that the low pressure of oxygen and deficiency of glycolysable sugar in the epididymis are responsible for the quiescence of spermatozoa therein. Bishop and Mathews (1952) deny the possible role of carbondioxide as an inhibitor of sperm motility on the basis pH measurements in the vas deferens of rabbit.

Since the sperms lack any intrinsic capacity of movement when in the seminiferous tubules, the question of the forces responsible for their movement from the testis tubules to the epididymis naturally arises. The mechanism responsible for the distally directed current of spermatozoa from the seminiferous tubules to the epididymis and further is not known. Belonoschkin (1929) believes that when loosened from the germinal epithelium of the seminiferous tubules, the sperms swim by their own strength through the rete tubules, vasa efferentia and epididymal tubules. My own observations on the motility of sperms *Anser melanotus*, *Copsychus saularis*, *Saxicoloides fulcata* and *Bubulcus ibis* however clearly show that they lack any capacity of independent movement till they reach the epididymis.

Oslund (1928), Young (1931) and Reid and Cleland (1957) have suggested that the continuous production of secretion in the seminiferous tubules is sufficient to maintain the current in which sperms are directed towards the vas-deferens. The part played by the cilia present in the vasa efferentia (Young, 1931, Roosen Runge, 1951); peristaltic movements of ductus epididymis aided by their increasing diameter (Cross, 1955, Risley and Turbyfill, 1957) and the capillary force of the epididymal tubules have also been advocated in this connection. During my studies on the seasonal histological changes in the testes of *Anser melanotus* (in press), I have observed that just before the onset of reproductive season, there is a marked development of elastic connective tissue fibres in the intertubular spaces and around the seminiferous tubules. I believe that in addition to other factors, the initial discharge of spermatozoa from the testis tubules is also aided by the contraction of elastic connective tissue fibres present around them. Craig Bennet (1931) has made similar observations in *Gasterosteus aculeatus*. Young (1929a, 1929b, and 1931) maintains that 'the functional changes such as acquisition of the capacity of independent movement by the sperms during their passage through the epididymis represent nothing more than a continuation of changes which occur while the sperms are still in the testis'. He denies the existence of any new stimulus to sperm development in the epididymis which is not present in the testis and believes that it is the time factor in the passage of sperm through

the epididymis which is important for the completion of their development culminating in the functional maturity of sperms.

Redenz (1926) suggests that in the elasmobranchs, the epididymal secretion forms a microscopically invisible envelope around the sperms which make them more resistant to the injurious factors in the environment.

Braus and Redenz (1924), Lasley and Bogart (1944), Gresson and Zlotnik (1945), Rao and Berry (1949), Branton and Salisbury (1947) and Hancock (1955 and 1957) believe that the maturation of sperms in the epididymis is accompanied by the migration of a cytoplasmic droplet from the neck of the spermatozoa to the distal end of the middle piece. Hancock (1955) has reported that in bulls this phenomenon happens in the caput epididymis and in the boars it takes place in the corpus and cauda epididymis also. It is believed that at ejaculation the droplet is usually lost from the spermatozoon.

Bishop and Walton (1960) also state that 'although the term spermateleosis is usually applied to the development of spermatid within the testis, there is evidence that spermateleosis is actually completed in the ductus epididymis because it is here that the spermatozoa undergo a process of maturation during which they acquire their functional competence'.

I do believe that a period of stay in the epididymis is necessary for the ripening of sperms but I do not agree with Young that the developmental changes which take place in the sperms during this period are merely a continuation of changes which begin in the testis. The stimulus provided to sperm development in the epididymis is different from the one present in the testis. The ripening changes which occur in the avian sperms in the epididymis are conditioned by the stimulus released by the epididymal secretion. The ripening changes are not inherent in the cytoplasm of the sperms. Moreover Young (1929a, b and 1931) does not give any idea of time taken for the passage of sperms through the epididymis or to what extent it is modified by the frequency of copulation and by other factors. Tournade and Delcarte (1913), Braus and Redenz (1924) and Lanz (1924 and 1926) also maintain that the developmental changes which are important for the successful functioning of sperms are due to a specific action of the epididymal secretion. The epididymal secretion brings about certain definite changes in the sperm cytoplasm and gives them an optimal functional ability. Lanz (1929) holds similar view regarding the functional maturation of sperms.

However, I do not agree with Lanz (1929) that the epididymis can preserve the vitality of sperms till they are discharged. My observations are that the non-ejaculated sperms left over in the epididymis of the birds after the expiry of the breeding season meet destruction in one way or the other (Mehrotra 1962c). The functional maturation of sperms and preservation of their vitality are two unrelated phenomena. Munro (1938) has also remarked that the mechanism governing the ripening process of sperms is not identical to that concerned in preserving sperm life. Once the functional maturity has been attained, there is no force in the epididymis which can prevent the ageing of sperms. Young (1931) has also suggested 'that the emphasis should be shifted from the conception of the epididymis as a sperm reservoir acting to preserve the sperms which have attained a certain level of development in a state of static maturity to the conception of the epididymis as an organ of sperm development'.

#### Summary :

The epithelial cells of the epididymal tubules of *Anser melanotos*, *Saxicolaurus fulicatus* and *Copsychus saularis* become secretory at the onset of the respective

reproductive periods of these birds. The secreted droplets which are lipoidal are discharged into the lumina of the epididymal tubules.

The sperms of birds acquire the capacity of independent movement only after a period of stay in the epididymis and lack this capacity so long as they are in the testis tubules.

The ripening of sperms *e.g.* acquisition of motility etc. is due to the specific action of the epididymal secretion.

The initial discharge of sperms from the testis tubules is also aided by the contraction of elastic connective tissue fibres which develop around them before the onset of reproductive period.

#### Acknowledgements :

The author gratefully acknowledges the facilities of work and valuable suggestions received from Dr. K. C. Bose, D.Phil., Head of Department of Zoology, Ranchi University, Ranchi. I am also indebted to Prof. M. D. L. Srivastava, D.Sc., Professor and Head of Department of Zoology, University of Allahabad, for kindly going through the manuscript and enlightening me with much helpful criticism and advice.

#### References :

- Bishop, D. W. Sperm motility. *Physiol. Rev.*, **42** : 1, 1962.
- and Mathews, H. P. The significance of intravas pH in relation to sperm motility. *Science*, **115** : 209, 1952.
- Bishop, M. W. H. and Hancock, J. L. The evaluation of bull semen. *Vet. Rec.*, **67** : 363, 1955.
- and Walton, A. Spermatogenesis and structure of mammalian spermatozoa (in Marshall's Physiology of Reproduction, Vol. I, Part 2, 3rd Ed., edited by A. S. Parkes, Longmans Green & Co., London, 1960.
- Branton, C. and Salisbury, G. W. Morphology of spermatozoa from different levels of the reproductive tract of bull. *J. Anim. Sci.* **6** : 154, 1947.
- Braus, H. and Redenz, E. Nebenhoden und Samenfad. *Z. ges. Anat.* **58** : 121, 1924.
- Craig Bennet, A. The reproductive cycle of the three spined stickleback, *Gasterosteus aculeatus*. *Philos. Trans. (B)*, **219** : 197, 1931.
- Cross, B. A. The posterior pituitary gland in relation to reproduction and lactation. *Brit. med. Bull.*, **11** : 151, 1955.
- Gresson, R. A. R. and Zlotnick, I. A comparative study of the cytoplasmic components of the male germ cells of certain mammals. *Proc. Roy. Soc. Edin. (B)* **62** : 117, 1945.
- Gunn, R. M. C. Fertility in sheep. *Bull. Coun. Sci. Industr. Res. Australia*, No. 47, 1936.
- Hancock, J. L. The disintegration of bull spermatozoa. *Vet. Rec.* **67** : 825, 1955.
- The cytoplasmic beads of boar spermatozoa. *J. Endocrin.*, **14** : 38, 1957.
- The structure of spermatozoa. *Vet. Rec.* **69** : 996, 1957.

- Hartman, C. G. Ovulation, fertilization and transport and viability of eggs and spermatozoa. (in Sex and Internal Secretions, 2nd Ed., edited by E. Allen, William and Wilkins & Co. London), 1939.
- Lanz, T. von. Die Nebenhoden einiger Säugetiere als Samenspeicher. *Verh. anat. Ges. Vers.*, **33** : 106, 1924.
- Ueber Bau und Function des Nebenhoden und seine Abhängigkeit von der Keimdrüse. *Z. Anat.* **80** : 177, 1926.
- Die relative Acidität in den einzelnen Abschnitten des männlichen Genitalapparates der Ratte und ihre hormonale Bedingtheit. *Pflug. Arch. ges. Physiol.*, **23** : 181, 1929.
- Lasley, J. F. and Bogart, R. A comparative study of the epididymal and ejaculated spermatozoa of the boar. *J. Anim. Sci.*, **3** : 360, 1944.
- Mehrotra, P. N. On the cyclical changes in the epididymis of *Anser melanotus*. *Quart. J. micros. Sci.*, **301** (3) : 377, 1962a.
- Mehrotra, P. N. Seasonal histological changes in the testes of *Copsychus saularis*. *La Cellule* (in press), 1962b.
- The fate of non-ejaculated spermatozoa in avian epididymis. *Current Science*, June, **63** : 265, 1963b.
- Munro, S. S. Motility and fertilising capacities of fowl sperm in the excretory ducts. *Proc. Soc. exp. Biol.* **33** : 255, 1935.
- The effect of testis hormone on the preservation of sperm life in the vas deferens of the fowl. *J. exp. Biol.*, **51** : 186, 1938a.
- Functional changes in sperm during their passage through the excurrent ducts of the male. *J. exp. Zool.*, **79** : 71, 1938b.
- Oslund, R. M. Seasonal modifications in the testis of vertebrates. *Quart. Rev. Biol.*, **3** : 254, 1928.
- Rao, C. K. and Berry, R. O. The cytoplasmic drop and the cytoplasmic cap in the development of boar spermatozoa. *Amer. J. vet. Res.*, **10** : 357, 1949.
- Observations on the cytoplasmic drop and cytoplasmic cap in sperm development of domestic sheep, domestic goats and wild sheep. *Indian J. vet. Sci.*, **20** : 47, 1950.
- Redenz, E. Versuch einer biologischen Morphologie des Nebenhoden, II, *Arch. Entw. Mech. Org.*, **106** : 290, 1925.
- Nebenhoden und Spermienbewegung. *Wurzburg, Abh. prakt. Med.*, **4** : 5, 1926.
- Reid, B. L. and Cleland, K. W. The structure and function of the epididymis I. The histology of the rat epididymis. *Aus. J. Zool.*, **5** : 223, 1957.
- Risley, P. L. and Turbyfill, C. Studies in vivo of the contractile behaviour of the epididymis. *Anat. Rec.*, **128** : 607, 1957.
- Roosen Runge, E. C. Motions of the seminiferous tubules of rat and dog. *Anat. Rec.*, **190** : 413, 1951.
- Salisbury, G. W. and Cragle, R. G. Freezing point depressions and mineral levels of fluids of the ruminant male reproductive tract. *Proc. 3rd Int. Congr. Anim. Reprod., Cambridge*, **1** : 25, 1956.

- Simeone, F. A. A neuromuscular mechanism in the ductus epididymis and its impairment by sympathetic denervation. *Amer. J. Physiol.*, **103** : 582, 1933.
- and Young, W. C. A study of the function of the epididymis. IV. The fate of non-ejaculated spermatozoa in the genital tract of the male guineapig. *J. exp. Biol.*, **8** : 163, 1931.
- Tournade, A. and Delcarte, J. Difference de motilite des spermatozoides preleves dans les divers segments de l'epididymis. *C. R. Soc. Biol.*, **74** : 738, 1913.
- Walton, A. The initiation of motility in mammalian spermatozoa. *Studies in Fertility*, **8** : 53, 1956.
- White, W. E. The effect of hypophysectomy on the survival of spermatozoa in the male rat. *Anat. Rec.* **54** : 253, 1932.
- Witschi, E. Quantitative studies on the seasonal development of deferent ducts in passerine birds. *Journ. exp. Zool.*, **100** : 549, 1945.
- Yochem, D. E. A study of motility and resistance of rat spermatozoa at different levels in the reproductive tract. *Physiol. Zool.*, **3** : 309, 1930.
- Young, W. C. A study of the function of the epididymis. I. Is the attainment of full spermatozoan maturity attributable to some specific action of the epididymal secretion. *J. Morph.*, **47** : 479, 1929a.
- A study of the function of the epididymis. II. The importance of an ageing process in sperm for the length of the period during which fertilizing capacity is retained by sperms isolated in the epididymis of the guineapig. *J. Morph.*, **84** : 475, 1929b.
- A study of the function of the epididymis. III. Functional changes undergone by the spermatozoa during their passage through the epididymis and vas deferens of guineapig. *J. exp. Biol.* **8** : 151, 1931.

# OBSERVATIONS ON THE VEGETATION OF KHANDESH (MAHARASHTRA)

By

S. K. JAIN

*Botanical Survey of India, Calcutta*

and

U. R. DESHPANDE

*Botanical Survey of India, Poona*

[Received on 24th April, 1964]

## Introduction

The area of study comprised the districts of East Khandesh and West Khandesh in Maharashtra state; it is situated approximately between 20° and 22°N., and 74° and 76°E. The climate is, in general, hot and dry. The average annual rainfall varies from 49 to 73.5 cm and it falls chiefly during the four months June to September.

The northern and western parts of the area are hilly, having dense, dry or moist deciduous, forests. The central plain area of the Tapti river basin is fertile and under extensive cultivation. The south-eastern and eastern parts are devoid of large mountains and are comparatively drier. Geologically the area is a part of the Deccan plateau, which is formed of the Trap rock system. There are several high trap hills which stand out prominently in the area. The soil is generally shallow and gravelly, and light brown in colour. The bare rock is exposed at many places. In the beds of rivers and smaller rivulets (nalas) the soil is sandy and moist; marshy situations are occasionally met with.

The area has been scantily explored botanically. There are references of some localities of Khandesh in Cooke's Flora of Bombay (1908) and in Hooker's Flora of British India (1872-1897). Mahabale and Karnik (1960) and Karnik (1961) explored some parts of the district for ecological studies. Puri, Jain and Deshpande (1960) described the grasslands of certain spots of this region. The rugged topography of the area, bad communications and absence of industrialisation have still left many spots in Khandesh botanically very interesting.

During the years 1957 to 1959, plant collections were made at Palasner, Pansemal—Dara range, Unupdeo, Nandurbar, Ashta, Kharakbharak nala, Hisala, Dhulia, Kondaibari and Pedke and Laling Kurans. The list of plants collected from this region is given in Appendix. This list is not claimed to be a complete flora of the district; however, it includes all the plants commonly occurring in the areas studied. As far as possible the nomenclature of the plants has been brought up to date; the names of some of the common plants have recently been changed, these are indicated in the Appendix.

## **Vegetation**

The vegetation of Khandesh comprises chiefly deciduous forests, mostly dry deciduous, at places tending to be moist deciduous. Due to biotic influences, the vegetation occasionally degrades into scrub forests or even poor grasslands. These three types of vegetation are described below.

### **(i) Moist deciduous forests**

#### **(a) Kondaibari—Sakri range**

There is a ghat area at Kondaibari about 80 km west of Dhulia on Surat road. The vegetation was studied in the valley and on a slope from nala to Kondaibari village. The forest is dense and the vegetation is of moist deciduous type. The chief tree species are *Tectona grandis*, *Lannea coromandelica*, *Boswellia serrata*, *Garuga pinnata*, *Gmelina arborea*, *Anogeissus latifolia*, *Acacia chundra*, *A. leucophloea*, *Miliusa tomentosa*, *Ficus* sp. and *Diospyros* sp. Trees of *Pongamia pinnata* and *Mangifera indica* are common in the valley.

In the understorey, *Wrightia tinctoria* and small trees of *Anogeissus* are more common. The climbers in the forest are chiefly species of *Cissus*, *Dioscorea* and *Spatholobus*. The shrub growth comprises chiefly *Grewia*, *Helicteres*, *Cassia* and saplings of above noted tree species. Barren hill slopes or slopes covered with sparse growth of trees of *Boswellia serrata* and *Acacia* species are seen in the vicinity of the road to this ghat area. *Cassia auriculata* grows commonly in lower parts of the slopes. There is heavy grazing by sheep owned by the people of Ghelari community. Level areas near Sakri were observed to be heavily eroded by shallow, but wide-spread, gullies. The shrub *Woodfordia fruticosa* is common on the freshly exposed soil on the cut faces along the road.

#### **(b) Satpura block at Palasner**

This area is situated in the Satpura ghats on the boundary of Khandesh and Nimar. These forests are also Teak—*Terminalia* forests. The tallest trees here are of *Albizia procera*, these are frequently met; some *Terminalia* trees also reach their height. The common trees in the second storey are *Madhuca indica*, *Lannea coromandelica*, *Garuga pinnata*, *Bridelia retusa* and *Boswellia serrata*. Occasionally trees of *Soyimida febrifuga*, *Caesalpinia* sp., *Butea monosperma*, *Morinda tinctoria* and *Randia* sp. are also found. Trees of *Schleichera oleosa* and *Pongamia pinnata* are common along nala. The robust climbers of *Combretum extensum* are a conspicuous feature here; they reach the top of the largest trees. Other climbing plants are species of *Cissus*, *Cocculus*, *Cissampelos*, *Dioscorea* and some plants of the Cucurbitaceae. Commonest shrubs are *Helicteres* and *Grewia*.

#### **(c) Hisala—Mahadeo Dandya forest**

Teak is the commonest tree in this forest, its regeneration is also abundant. *Anogeissus latifolia* is also very common. Other trees frequently occurring in the area are *Lannea*, *Cassia fistula*, *Acacia chundra*, *A. nilotica*, *Hardwickia binata* and *Boswellia serrata*. *Maytenus emarginata* and *Mimosa rubicaulis* are common shrubs; *Helicteres isora* is also frequently seen. *Mimosa* grows in comparatively more open areas. *Vitex negundo* is common all along the nala banks. An adjacent area about 3 km from Hisala has abundance of *Hardwickia binata* trees.

### **(ii) Dry deciduous forests**

#### **(a) Sulia**

The hills at Sulia are the continuation of the same ranges as studied at Hisala but are the southern and more gradual slopes of the Satpuras. The

forests are dry deciduous composed chiefly of *Anogeissus latifolia* and *Acacia* species. Other trees associated here are *Lannea*, *Tectona*, *Soyimida*, *Morinda*, *Zizyphus mauritiana*, *Hardwickia binata*, *Bauhinia racemosa*, *Maytenus emarginata* and *Butea monosperma*.

(b) *Kidukadar*

This forest is near Ashta in Nandurbar range. Teak is the commonest tree in top storey. Regeneration of teak is also common. Trees of *Acacia chundra*, *A. nilotica*, *Bauhinia racemosa*, *Boswellia serrata* and *Zizyphus* species are frequently met. Small trees and shrubs of *Maytenus emarginata*, *Acacia intsia* and *Mimosa nala*. Few *Euphorbia* bushes were seen on hard rocky surfaces. The forest is reserved, but illicit lopping or felling is a common practice.

Cultivation of *Capsicum annum*, *Cajanus cajan* and *Ricinus communis* was observed in outskirts of the forest.

(c) *Takya*

The Takya hill and the Fort hill near Dhulia have a deciduous forest of *Boswellia serrata*, *Bauhinia racemosa*, *Hardwickia binata*, *Lannea*, *Zizyphus* species and occasionally *Dolichandrone falcata* and *Heterophragma quadriloculare*. As the tree growth is sparse and there is abundant sunlight available to the ground flora, the herbaceous vegetation is dense. In rainy season the *Chlorophytum* plants are conspicuous.

(d) *Kharakbharak nala*

Teak is the commonest tree in the top storey here. *Anogeissus latifolia*, *Bauhinia racemosa* and *Zizyphus rugosa* are the commonest trees in understorey. Other common trees in the area are *Acacia nilotica*, *Boswellia serrata*, *Hardwickia binata*. The commonest shrubs are *Nyctanthes arborescens* and *Balanites aegyptiaca*.

(e) *Chopda—Unupdeo*

*Hardwickia binata* is the commonest tree of this spot ; associated with it are trees of *Boswellia*, *Terminalia*, *Anogeissus* and *Dolichandrone falcata* (fig. 4) etc. *Maytenus emarginata* and *Nyctanthes arborescens* are most abundant in the understorey.

(iii) **Scrublands**

*Pedke Kuran* is situated about 45 km northwest of Dhulia. There are several barren eroded wastelands and agricultural fields near the area. The roadside plants are bushes of *Cassia*, *Maytenus* and *Balanites*. The general physiognomy of the vegetation of the Kuran is of a scrubland, though trees of *Hardwickia* are common nearer to the roadside. Trees of *Cordia rothii* and *Zizyphus* are frequently present in the area. The commonest shrubs are of *Acacia*, *Mimosa*, *Maytenus*, *Securinega*, *Grewia*, *Rhus* and *Clerodendrum*. A number of climbers, such as *Asparagus*, *Cocculus*, *Rivea*, *Rhynchosia* and *Dalechampia* grow among the bushes of shrubs.

The ground is covered with dense growth of grasses, comprising species of *Heteropogon*, *Eremopogon*, *Microchloa*, *Tetrapogon*, *Chrysopogon*, *Tripogon*, *Panicum*, *Setaria*, *Ischaemum*, and *Melanocenthrus*. Sedges occur in depressions. A few *Boerhaavia* and *Indigofera* species trail on the rocky ground.

Trees of *Albizia lebbek*, *Hardwickia binata*, *Azadirachta indica*, *Gmelina arborea*, *Cassia fistula* and *Dalbergia* sp. have been planted by the forest department. Similar scrub vegetation is found at Nardana area. Small trees of *Acacia nilotica* and *Dichrostachys cinerea* are occasionally seen here.

## APPENDIX

### **Annonaceae**

- \**Annona reticulata* L.
- Annona squamosa* L.
- Miliusa tomentosa* (Roxb.) Sincl.

### **Menispermaceae**

- Cissampelos pareira* L.
- Cocculus hirsutus* (L.) Diels

### **Nymphaeaceae**

- Nelumbo nucifera* Gaertn.

### **Papaveraceae**

- Argemone mexicana* L.

### **Capparidaceae**

- Cleome chelidonii* L.f.
- C. monophylla* L.
- C. simplicifolia* (Camb.) Hook.f. and Th.
- C. viscosa* L.
- Gynandropsis gynandra* (L.) Briq.
- = *Cleome gynandra* L.
- Maerua ovalifolia* Camb.
- = *M. arenaria* var. *glabra* Hook.f. and Th.
- Crateva nurvala* Buch.-Ham.
- Capparis decidua* (Forsk.) Edgew.
- C. grandis* L.f.
- C. sepiaria* L.

### **Violaceae**

- Hybanthus enneaspermus* (L.) Muell.

### **Cochlospermaceae**

- Cochlospermum religiosum* (L.) Alston

### **Flacourtiaceae**

- Flacourtia indica* (Burm.f.) Merr.

### **Polygalaceae**

- Polygala chinensis* L.
- P. erioptera* DC.

### **Caryophyllaceae**

- Polycarpaea corymbosa* (L.) Lam.

### **Portulacaceae**

- Portulaca oleracea* L.

### **Malvaceae**

- Sida acuta* Burm.f.

(\*Cultivated plants).

- S. glutinosa* Cav.

= *S. mysorensis* Wt. and Arn.

- S. grewoides* G. P. and R.

= *S. ovata* Forsk.

- S. veronicifolia* Lamk.

- Abutilon indicum* (L.) Sweet

- Abelmoschus esculentus* (L.) Moench.

- A. manihot* (L.) Medik.

- Hibiscus caesioides* Goercke.

- H. cannabinus* L.

- H. micranthus* L.f.

- \**Gossypium* sp.

### **Bombacaceae**

- Salmaia malabarica* (DC.) Schott.

### **Sterculiaceae**

- Sterculia urens* Roxb.

- Helicteres isora* L.

- Eriolaena candollei* Wall.

- Waltheria indica* L.

### **Tiliaceae**

- Corchorus olitorius* L.

- C. tridens* L.

- C. trilobularis* L.

- Grewia* spp.

### **Zygophyllaceae**

- Tribulus terrestris* L.

### **Geraniaceae**

- Biophytum sensitivum* (L.) DC.

### **Rutaceae**

- Feronia limonia* (L.) Swingle

### **Simaroubaceae**

- Ailanthus excelsa* Roxb.

- Balanites aegyptiaca* (L.) Delile

### **Burseraceae**

- Boswellia serrata* Roxb.

- Garuga pinnata* Roxb.

### **Meliaceae**

- Azadirachta indica* A. Juss.

- Soyimida febrifuga* Andr.

### Celastraceae

*Maytenus emarginata* (Willd.) Ding Hu

### Rhamnaceae

*Ventilago calyculata* Tul.  
*Zizyphus mauritiana* Lam.  
*Z. nummularia* (Burm.f.) Wt. and Arn.  
*Z. oenoplia* Mill.  
*Z. rugosa* Lamk.  
*Z. xylopyrus* Willd.

### Vitaceae

*Leea indica* (Burm.) Merr.  
*Cissus* sp.

### Sapindaceae

*Cardiospermum halicacabum* L.  
*Schleichera oleosa* (Lour.) Oken  
*Sapindus emarginatus* Vahl.

### Anacardiaceae

*Rhus mysurensis* Heyne ex Wt. and Arn.  
*Mangifera indica* L.  
*Buchanania lanzan* Spreng.  
*Lannea coromandelica* (Hout.) Merr.

### Moringaceae

*Moringa oleifera* Lamk.

### Papilionaceae

*Heylandia latebrosa* DC.  
*Crotalaria filipes* Benth.  
*C. bifaria* L.f.  
*C. juncea* L.  
*C. medicaginea* Lamk.  
*C. mysorensis* Roth.  
*Medicago sativa* L.  
*Indigofera cordifolia* Heyne ex Roth  
*I. glandulosa* Roxb. ex Willd.  
*I. linifolia* Retz.  
*I. paucifolia* Del.  
= *I. oblongifolia* Forsk.  
*I. tinctoria* L.  
*I. trifoliata* L.  
*I. trita* L.f.  
*Psoralea corylifolia* L.  
*Tephrosia paucifolia* Grahm.  
= *T. senticosa* Pers.  
*T. purpurea* Pers.  
*Sesbania sesban* (L.) Merr.  
*Taverniera nummularia* Baker  
= *T. cuneifolia* Arn.  
*Alysicarpus monilifer* DC.  
*A. rugosus* DC.  
= *A. glumaceus* (Vahl) DC.

*A. tetragonolobus* Edgew.  
*Desmodium gangeticum* (L.) DC.  
*D. triflorum* (L.) DC.  
*Abrus precatorius* L.  
*Teramnus labialis* (L.f.) Spreng.  
*Spatholobus* sp.  
*Butea monosperma* (Lam.) Taub.  
*B. superba* Roxb.  
*Canavalia gladiata* (Jacq.) DC.  
*Phaseolus aconitifolius* Jacq.  
*P. aureus* Roxb.  
\**P. mungo* auct. non L.  
= *P. angularis* (Willd.) W. F. Wight  
*P. sublobatus* Roxb.  
= *P. radiatus* L.  
*P. vulgaris* L.  
*Atylosia scarabeoides* (L.) Benth.  
*Rhynchosia minima* (L.) DC.  
*Dalbergia lanceolaria* L.f.  
*D. latifolia* Roxb.  
*D. paniculata* Roxb.  
*D. sissoo* Roxb.  
*Pongamia pinnata* (L.) Pierre  
\**Arachis hypogaea* L.  
\**Cajanus cajan* (L.) Millsp.  
\**Cicer arietinum* L.  
*Dolichos lablab* L.

### Caesalpiniaceae

*Caesalpinia bonduc* (L.) Roxb.  
\**Caesalpinia pulcherrima* Swartz  
*Delonix elata* (L.) Gamble  
*Parkinsonia aculeata* L.  
*Cassia auriculata* L.  
*C. fistula* L.  
*C. glauca* Lamk.  
= *C. surattensis* Burm.f.  
*C. mimosoides* L.  
*C. occidentalis* L.  
*C. sophora* L.  
*C. tora* L.  
*Hardwickia binata* Roxb.  
= *Kingiodendron pinnatum* (Roxb.)  
Harms. (fig. 1)  
*Tamarindus indica* L.  
*Bauhinia racemosa* Lamk.

### Mimosaceae

*Prosopis spici gera* L.  
*P. juliflora* DC.  
*Dichrostachys cinerea* (L.) Wt. & Arn.  
*Mimosa hamata* Willd.  
*M. rubicaulis* Lamk.

*Acacia arabica* (Lamk.) Willd.  
 = *A. nilotica* (L.) Del. var. *tomentosa*  
 (Benth.) Cuff.  
*A. chundra* (Roxb.) Willd.  
*A. eburnea* Willd.  
*A. intsia* Willd.  
 = *A. caesia* Willd.  
*A. leucophloea* Willd.  
*Albizia lebbek* (L.) Benth.  
*A. procera* Benth.  
*Pithecellobium dulce* (Roxb.) Benth.

#### Combretaceae

*Terminalia arjuna* Wt. & Arn. (fig. 3).  
*T. bellirica* (Gaertn.) Roxb.  
*T. crenulata* Roth.  
*Anogeissus latifolia* Wall. ex Bedd. (fig. 1).  
*Combretum extensum* Roxb.  
 = *C. latifolium* Blume  
*C. ovalifolium* Roxb.

#### Myrtaceae

*Syzygium cumini* (L.) Skeels.  
*Eugenia heyneana* Duthie  
 = *Syzygium heyneana* Wall. ex Gamble  
 \**Psidium guajava* L.

#### Lythraceae

*Ammannia baccifera* L.  
*A. tenuis* Clarke  
 = *Rotala serpyllifolia* (Roth.) Brem.  
*Woodfordia fruticosa* (L.) Kurz  
*Lawsonia inermis* L.  
*Lagerstroemia lanceolata* Wall.

#### Onagraceae

*Jussiaea suffruticosa* L.

#### Cucurbitaceae

*Trichosanthes cucurina* L.  
*Momordica dioica* Roxb.  
*Cucumis callosus* (Rottl.) Cogn.  
*Citrullus colocynthis* Schrad.  
*Blastania garcinii* (L.) Cogn.

#### Aizoaceae

*Trianthema decandra* L.  
*Mollugo pentaphylla* L.  
*Glinus lotoides* L.  
*G. oppositifolius* (L.) A. DC.

#### Umbelliferae

*Centella asiatica* (L.) Urban

#### Rubiaceae

*Adina cordifolia* (Roxb.) Hook.f. ex  
 Brandis

*Mitragyna parvifolia* (Roxb.) Korth.  
*Dentella repens* (L.) Forst.  
*Oldenlandia auricularia* (L.) K. Schum.  
 = *Exallage auricularia* (L.) Brem.  
*Hedyotis nitida* Wt. & Arn.  
*Randia brandisii* Gamble  
 = *Xeromphis spinosa* (Thunb.) Keay.  
*Gardenia turgida* Roxb.  
*Ixora arborea* Roxb. ex Sm.  
*Pavetta indica* auct. non L.  
 = *P. crassicaulis* Brem.  
*Morinda citrifolia* L.  
*M. tinctoria* Roxb.  
 = *M. coreia* Buch.-Ham.  
*Borreria stricta* (L.f.) Schum.

#### Compositae

*Vernonia cinerea* Less.  
*Ageratum conyzoides* L.  
*Cyathocline purpurea* (Don.) Kuntze  
*Grangea maderaspatana* Poir.  
*Blumea lacera* (Burm.f.) DC.  
*B. malcomii* (Cl.) Hook.f.  
*B. membranacea* DC.  
*B. mollis* (Don) Merr.  
*B. obliqua* (L.) Druce  
*Sphaeranthus indicus* L.  
*Gnaphalium indicum* L.  
*Vicoa indica* (Willd.) DC.  
*Pulicaria wightiana* G.B. Clarke  
*Caesulia axillaris* Roxb.  
*Lasagea mollis* Cav.  
*Acanthospermum hispidum* DC.  
*Xanthium strumarium* L.  
*Eclipta prostrata* (L.) L.  
*Blainvillea acmella* (L.f.) Philipson  
*Glossocardia bosvallea* (L.f.) DC.  
*Bidens biternata* (Lour.) Merr. & Sherff  
*Tridax procumbens* L.  
*Flaveria repanda* Lag.  
*Emilia sonchifolia* (L.) DC.  
*Notonia grandiflora* DC.  
*Senecio edgeworthii* Hook.f.  
*Echinops echinatus* Roxb.  
*Goniocaulon glabrum* Cass.  
*Tricholepis radicans* DC.  
*Dicoma tomentosa* Cass.  
 \**Carthamus tinctorius* L.

#### Sapotaceae

*Madhuca indica* Gmel.  
 = *M. longifolia* (L.)  
 McBride var. *latifolia* (Roxb.) Chev.

### **Ebenaceae**

- Diospyros melanoxylon* Roxb.  
*D. montana* Roxb.

### **Oleaceae**

- Jasminum malabaricum* Wt.  
*J. multiflorum* (Burm.f.) Andr.  
*Nyctanthes arbortristis* L.

### **Salvadoraceae**

- Salvadora persica* L.

### **Apocynaceae**

- Holarrhena antidysenterica* (L.) Wall. ex  
G. Don  
*Wrightia tinctoria* R.Br.  
*Nerium indicum* Mill.

### **Asclepiadaceae**

- Hemidesmus indicus* (L.) Schult.  
*Cryptolepis buchanani* Roem. & Schult.  
*Calotropis gigantea* (L.) R.Br.  
*C. procera* R.Br.  
*Pergularia daemia* (Forsk.) Chiov.  
*Sarcostemma acidum* (Roxb.) Voigt  
*Marsdenia volubilis* (L.f.) Cooke  
= *Dregea volubilis* (L.) Benth. ex  
Hook.f.  
*Leptadenia reticulata* Wt. and Arn.  
*Ceropegia attenuata* Hook.

### **Loganiaceae**

- Strychnos potatorum* L.f.

### **Gentianaceae**

- Exacum pedunculatum* L.  
*Enicostemma verticillatum* (L.) Engl.  
*Hoppea dichotoma* Willd.  
*Canscora decurrens* Dalz.  
*C. diffusa* (Vahl) R.Br.

### **Boraginaceae**

- Cordia dichotoma* Forst.f.  
*C. rothii* Roem. and Schult.  
= *C. gharaf* (Forsk.) Ehrenb. ex Asch.  
*Ehretia aspera* Willd.  
*Coldenia procumbens* L.  
*Heliotropium ovalifolium* Forsk.  
*H. zeylanicum* Wall.  
*Trichodesma indicum* (L.) R.Br.

### **Convolvulaceae**

- Cuscuta chinensis* Lamk.  
*Evolvulus alsinoides* L.  
*Ipomea pestigridis* L.  
*Rivea hypocrateriformis* Choisy

### **Solanaceae**

- Solanum nigrum* L.  
*S. incanum* L.  
*S. surattense* Burm.f.  
*Nicandra physaloides* (L.) Gaertn.  
\**Capsicum annum* L.

### **Scrophulariaceae**

- Verbascum chinense* (L.) Santapau  
*Kickxia ramosissima* (Wall.) Janch.  
*Bacopa monnieri* (L.) Pennell  
*Striga euphrasioides* Benth.  
= *S. angustifolia* (Don) Saldanha  
*S. gesneroides* (Willd.) Vatke ex Engl.  
*Sopubia delphinifolia* (Roxb.) G. Don  
*Lindenbergia indica* (L.) Kuntze

### **Bignoniaceae**

- Dolichandrone falcata* Seem. (fig. 4).  
*Heterophragma quadriloculare* (Roxb.)  
K. Schum.

### **Pedaliaceae**

- Sesamum indicum* L.  
*Martynia annua* L.

### **Acanthaceae**

- Elytraria acaulis* (L.f.) Lindau  
*Asteracantha longifolia* (L.) Nees  
= *Hygrophila auriculata* (Schum.) Heine.  
*Dipteracanthus patulus* (Jacq.) Nees  
*D. prostratus* (Poir.) Nees  
*Hemigraphis latebrosa* Nees  
*Dyschoriste depressa* Nees  
*Andrographis echioides* Nees  
*Barleria prionitis* L.  
*Rungia elegans* Dalz. and Gibs.  
*R. parviflora* Nees  
*Dicliptera* sp.  
*Justicia diffusa* Willd.  
*J. quinqueangularis* Koen. ex Roxb.  
*Adhatoda vasica* Nees  
*Peristrophe bicalyculata* Nees

### **Verbenaceae**

- Lantana camara* L. var. *aculeata* (L.)  
Mold.  
*Phyla nodiflora* (L.) Greene  
*Tectona grandis* L.f.  
*Gmelina arborea* Roxb.  
*Vitex negundo* L.

### **Labiatae**

- Ocimum americanum* L.  
*O. gratissimum* L.

- Q. sanctum* L.  
*Orthosiphon pallidus* Benth.  
*Plectranthus coetosa* Buch.-Ham.  
 = *P. japonicus* (Burm.f.) Koidz  
*Lavandula bipinnata* Kuntze  
*Anisomeles indica* (L.) Kuntze  
*Leucas lavandulaefolia* Rees.  
*L. longifolia* Benth.  
*L. stelligera* Wall. ex Benth.  
*L. urticifolia* R.Br.  
*Hyptis suaveolens* Poir.
- Nyctaginaceae**  
*Boerhaavia diffusa* L.  
*B. verticillata* Poir.
- Amaranthaceae**  
*Celosia argentea* L.  
*Digera muricata* (L.) Mart.  
*Amaranthus blitum* L. var. *oleracea*  
 Hook.f.  
*A. spinosus* L.  
*Achyranthes aspera* L.  
*Pupalia lappacea* Moq.  
*Alternanthera sessilis* (L.) DC.
- Polygonaceae**  
*Polygonum plebejum* R.Br.
- Aristolochiaceae**  
*Aristolochia bracteata* Retz.  
 = *A. bracteolata* Lam.
- Loranthaceae**  
*Dendrophthoe falcata* (L.f.) Etting.
- Santalaceae**  
*Santalum album* L.
- Euphorbiaceae**  
*Euphorbia hirta* L.  
*E. neriifolia* L.  
*E. thymifolia* L.  
*Bridelia retusa* Spreng.  
*Securinega leucopyrus* (Willd.) Muell.-Arg.  
*Phyllanthus maderaspatensis* L.  
*P. niruri* L.  
*Kirganelia reticulata* (Poir.) Baill.  
*Emblica officinalis* Gaertn.  
*Jatropha gossypifolia* L.  
*Chrozophora rottleri* (Geis.) Juss. ex  
 Spreng.  
*Acalypha indica* L.  
*A. malabarica* Muell.  
*Dalechampia* sp.  
 \* *Pedilanthus tithymaloides* (L.) Poir.  
 \* *Ricinus communis* L.
- Urticaceae**  
*Holoptelea integrifolia* (Roxb.) Planch.  
*Ficus benghalensis* L.  
*F. glomerata* Roxb.  
*F. hispida* L.f.
- Dioscoreaceae**  
*Dioscorea oppositifolia* L.
- Liliaceae**  
*Asparagus racemosus* Willd. var. *javanicus*  
 Baker  
*Iphigenia indica* (L.) A. Gray  
*Scilla hyacinthina* (Roth) McBride  
*Chlorophyllum attenuatum* Baker  
*C. laxum* R.Br.  
*C. tuberosum* (Roxb.) Baker
- Commelinaceae**  
*Cyanotis fasciculata* (Heyne ex Rottl.)  
 Roem. and Schult.
- Cyperaceae**  
*Cyperus rotundus* L.  
*Fimbristylis* sp.
- Gramineae**  
*Setaria nervosum* (Rottl.) Stapf  
*Lophopogon tridentatus* (Roxb.) Hack.  
*Apluda mutica* L.  
*Chrysopogon fulvus* (Spreng.) Chiov.  
*Dichanthium annulatum* (Forsk.) Stapf  
*Eremopogon foveolatus* (Del.) Stapf  
*Andropogon pumilus* Roxb.  
*Cymbopogon martinii* (Roxb.) Watson  
*Isilema laxum* Hack.  
*Heteropogon contortus* (L.) Beauv. ex  
 Roem. and Schult.  
*Digitaria adscendens* (H. B. K.) Henrard  
*Echinochloa colonum* (L.) Link  
*Pennisetum* sp.  
*Cenchrus ciliaris* L.  
*Aristida funiculata* Trin. and Rupr.  
*A. setacea* Retz.  
*Tragus biflorus* (Roxb.) Schult.  
*Perotis indica* (L.) Kuntze  
*Sporobolus diander* (Retz.) Beauv.  
*Eragrostis unioloides* (Retz.) Nees ex  
 Steud.  
*Melanocenchrus jacquemontii* Jaub. and  
 Spach.  
*Microchloa setacea* R.Br.  
*Tetrapogon* sp.  
*Cynodon dactylon* (L.) Pers.  
*Chloris dolichostachya* Lag.  
*Dactyloctenium aegyptium* (Desf.) Beauv.  
*Tripogon roxburghianus* (Steud.) Bhide

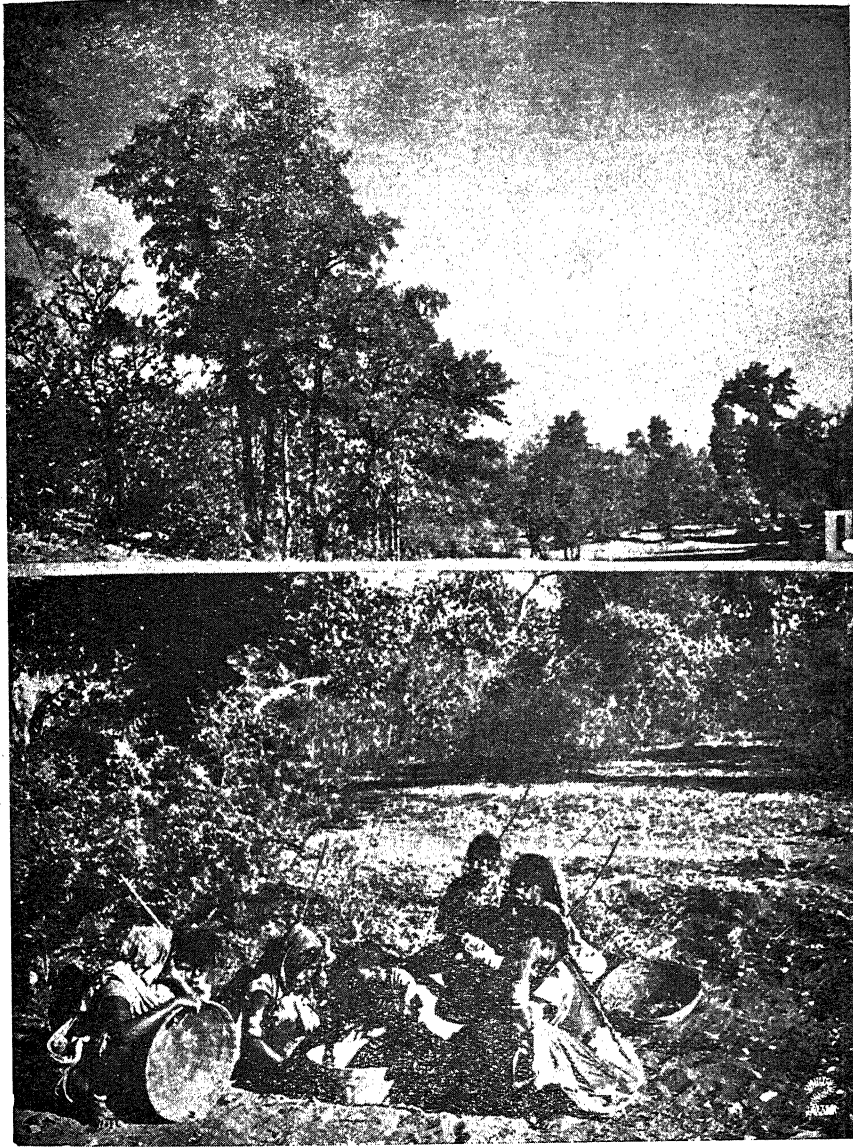


Fig. 1. A view of the forest at Pahla Dong in East Khandesh (on way to Deojhiri).  
From left : trees of *Tectona*, *Har wickia* (dark and tall) and *Anogeissus* (light and low trees).

Fig. 2. A group of Vanjari women in Ashta forest ; they indulge in illicit lopping and felling.



Fig. 3. Another view near Pahla Dong ; trees of *Terminalia arjuna* along both banks of a rivulet.

Fig. 4. A view inside the forest at Unupdeo ; close view of *Dolichandrone* tree in fruit.



